TEA INSECTS.

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AN ACCOUNT

OF THE

INSECTS AND MITES WHICH ATTACK THE TEA PLANT IN INDIA.

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BY

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PREFACE.

In January 1894, at the instance of the Hon. Mr. James Buckingham, C.I.E., Chairman of the Assam branch of the Indian Tea Association, a letter was addressed to the Trustees of the Indian Museum by the Government of India, in the Revenue and Agricultural Department, suggesting the desirability of publishing in a collected form the information already brought together in the Indian Museum upon the subject of tea blights. The matter was favourably received by the Trustees, and the following report has been drawn up under their instructions.

Attention was first directed to the insects and mites which attack the tea plant in India by Mr. S. E. Peal, then a tea planter in the Sibsagar District of Assam, who published a valuable paper on "mosquito blight" in the Journal of the Agricultural and Horticultural Society of India, Vol. IV, 1873. Mr. Peal described the effect of mosquito blight and warned the planting community of the extent of the injury likely to be occasioned by it. He further traced the insect through its various stages of development subsequent to emergence from the egg. In 1881 the late Mr. James Wood-Mason, at that time Deputy Superintendent of the Indian Museum, was deputed to Assam to investigate the matter. Mr. Wood-Mason's report appeared in 1884. In it he confirmed Mr. Peal's observations on the subject of mosquito blight, and added an account of the egg which he was the first to discover. He also traced the mite popularly known as "red spider" through its transformations upon the tea leaf.

Numerous other species have since been complained of by tea planters as causing injury to the bushes, and from time to time specimens have been sent to the Indian Museum with inquiries as to their indentity.

Some years since the study of the matter was taken up by the writer of this note as part of an extended investigation of the insects which attack crops generally in India. At first, owing to the unarranged condition of the general entomological collections of the Indian Museum, very few of the species that were forwarded in connection with injury to crops could be determined. Little by little, however, the collections have been largely arranged and the identity of the more important species ascertained.

The investigation of the habits and life-histories of the various insects, including the whole practical side of the question, has had to be confined to what could be ascertained, without leaving the Museum, from specimens and reports furnished by planters and other residents in the localities affected. This method of inquiry was very desirable in the first instance in order to ascertain the nature and scope of the outbreaks which would require investigation. It has been only an initial step, however, and taken by itself is necessarily inadequate. The cordial co-operation of many of those concerned, who have not only made observations themselves upon the lines suggested to them, but frequently forwarded living specimens in such condition that they could be kept under observation in rearing-cages in the Indian Museum, has enabled a surprising amount of information to be collected. The limit of useful work to be accomplished through this agency has now been to a large extent attained, and the results arrived at require, for their further elaboration, extensive and prolonged investigations which can only be carried out effectively in the field, where all the concomitant circumstances can be inquired into.

The prospect of further advance is a hopeful one, provided means can be found of carrying on the investigation upon a scale commensurate with its importance. Already, the information collected in connection with the habits and life-histories of many of the species is sufficient to indicate the possibility of adopting methods or treatment which have done wonders in dealing with corresponding forms in other parts of the world. Some of these methods have already been experimented upon with promising results in India, and are likely eventually to be adopted upon a large scale. Others have been suggested, but not yet taken up, while a third class have hitherto hardly so much as reached the ears of the great majority of the planting community.

In particular the insecticides, both liquid and gaseous, and the various forms of apparatus for applying them, now in general use in the United States, are worthy of special attention, while a field is open for the cultivation of beneficial parasitic forms, seemingly as promising as that which has yielded results of the greatest practical value against fluted scale in California.

The only sound basis for investigations directed to the prevention and mitigation of insect ravages lies in the careful study of the habits and life-histories of the species concerned. Researches in the field and in the laboratory, however, must not be divorced from each other, but must go hand in hand, supported by practical experiments upon a scale sufficient to exclude error. This has been the system adopted in the United States with the result of saving a very appreciable portion of the enormous damage previously caused by insect blights; and there is no apparent reason why similar procedure in India should not be productive

of similarly useful results, especially where such valuable crops as tea, indigo, and coffee are concerned.

The following report is intended to show the stage which the inquiry has reached in the case of the tea plant. It has been drawn up with a view both to facilitate reference to what has already been ascertained, and also to indicate the directions in which further research is desirable.

The record of the inquiries conducted in the Indian Museum has been kept in the pages of the periodical *Indian Museum Notes*. The report, therefore, is chiefly based upon this publication, supplemented where possible from the papers of other observers who have frequently been in communication with the present writer upon the subject of their inquiries.

Amongst works from which help has been received, special reference may be made to an admirable series of papers by Mr. E. E. Green, originally published in nineteen instalments in the *Ceylon Independent* in 1889. In these papers Mr. Green describes his observations on a number of species which attack the tea plant in Ceylon. Most of the insects he describes have also been recorded from India, and are therefore discussed fully in the following pages. Others again have not hitherto been recorded from India, so are merely alluded to briefly, the reader being referred for further particulars regarding them to Mr. Green's work, which should be in the hands of all interested in the subject.

In his recent work on the *Chemistry and Agriculture of Tea*, Calcutta, 1893, Mr. M. K. Bamber makes a number of suggestions, many of them of much practical value, for dealing with the various blights which attack the tea plant. The chapter which he devotes to the matter is arranged on the same plan as that adopted in the present report, his remarks, indeed, upon the entomology of the subject being in many cases transcribed from *Indian Museum Notes*. His recommendations, therefore, can easily be consulted by those concerned and, as his work will no doubt be in the hands of most Indian tea planters, it has been considered unnecessary to do more than refer to it in this place.

[When not otherwise acknowledged the figures in the following report have been drawn from the specimens by native artists in the Indian Museum, the majority being the work of Babu G. C. Chuckrabutty. Many of them have previously appeared in illustration of papers by the writer in the pages of *Indian Museum Notes*. With two exceptions the wood-cuts have been prepared by Messrs. West, Newman & Co., of London.

Owing to his absence from India the writer has been unable to revise the final proofs of this report; it is hoped, however, that the typographical errors which escape correction will not be of importance.]

THE TEA INSECTS OF INDIA.

INSECTA.

COLEOPTERA.

MELOLONTHINI.

Lachnosterna impressa, Burma—(= White grub). The larva (*i.e.* immature form) of this insect is the soft, white, curved grub shown in the left hand bottom figure. In 1891 it appeared in vast numbers in some of the Darjiling tea gardens, and made great havoc among young tea plants. In one garden it is reported (*vide Indian Museum Notes,* Vol. III, page 3) to have practically destroyed 100 acres of young tea as fast as it was planted. Its prevalence in other years is shown by the fact that in 1883 no less than 2,695,000 individuals were collected and destroyed in the public gardens, Darjiling, alone (*vide Indian Museum Notes,* Vol. I, page 59).

From what is known in connection with the habits of insects of the same sub-family in other parts of the world we can be practically certain that the life-history of *Lachnosterna impressa* is somewhat as follows:—

The beetle, a brown insect, depicted natural size in the upper part of the block, mates with another individual of the opposite sex, but otherwise almost exactly like itself. The female shortly afterwards lays

its eggs on the ground. From these eggs emerge small curved white grubs armed with powerful jaws with which they bite off the roots of plants. These grubs never quit the ground. They moult at intervals and gradually grow bigger until they become of the size shown in the left hand bottom figure, or even bigger than this. They then moult their skins for the last time and transform into white motionless creatures (or pupæ), one of which is depicted, natural size, in the right hand bottom figure. The pupa lies dormant for a time in the ground, and then its skin splits down the back, and out of it emerges the beetle which makes its way out of the ground. The beetle flies about for a time and perhaps eats a few leaves, but its chief object in life is to find a mate and to become the parent of another generation. Thus the circle goes on continuously.

With regard to the time spent by the insect in its various stages of growth all that we know is as follows. A number of nearly full-grown grubs, sent to the Indian Museum, Calcutta, from Darjiling in October 1891, remained in the earth at the bottom of the breeding-cage in which they were kept, until the following February, when a beetle emerged. This shows that the insect passes the cold weather in the ground, for in the moist warm climate of Calcutta it is certain to develop at least as fast as in the hills, and possibly considerably faster. The beetle of a species belonging to the same family has been noticed by the writer emerging in large numbers from the ground, on the Calcutta *maidan*, in the latter part of the hot weather, so the probabilities are that the hot season is the usual time for emergence. Under these circumstances the eggs would be likely to be laid about the beginning of the rainy season in Northern India; but this point requires confirmation. How long is spent by the grubs in the ground before they become full grown we do not know, but the fact that the European species *Melolontha vulgaris*, Fabr., spends more than three years in this stage,[1] while the American species *Macrodactylus subspinosus*, Fabr., spends the greater part of one year,[2] leads to the supposition that an equally long period may be required in India. Much, no doubt, depends upon the climate of the locality; for warmth and damp are almost certain to accelerate development, whereas dryness and cold retard it. In any case, a generation of the insect is almost certain to occupy one year, and it is quite possible that it takes two or even three years to complete.

On Ceylon coffee estates, where Melolonthini larvæ at one time proved very troublesome, the only method of treatment that seems to have been at all successful was digging out the grubs by hand; and this, though very costly, was generally admitted to be the most satisfactory method of dealing with the pest.

[1] Ormerod. [2] Packard.

Attempts have recently been made in Europe to destroy the grubs of an allied insect by inoculating them with the spores of a fungoid disease to which they are subject. This method of treatment, however, has not hitherto yielded any practical results, so cannot be recommended. In the case of a species which attacks the roots of vines in Europe, bisulphide of carbon is said to have been used with some success, but the writer is not in a position to say whether it is likely to be of any use in India. The simplest method of applying it is said to have been to make a hole near the main root of the vine by forcing a small stick into the earth, then to pour about half a teaspoonful of bisulphide of carbon into the hole, and plug it with earth pressed down by the foot.

CHRYSOMELIDÆ.

Diapromorpha melanopus, Lacord—(Orange beetle). This insect has been reported from Sibsagar, Assam, as eating the stems of tea shoots, so that they wither and droop (*vide Indian Museum Notes*, Vol. I, p. 106). It is bright orange yellow in colour, and has hence been dubbed the "Orange beetle."

The wood-cut shows the beetle as it appears from above and also from the side, both enlarged, also much magnified diagrams of the antenna and of one of the legs. The size of the insect in nature is indicated by the hair lines which show the length measured from the head to the posterior portions of the elytra.

The species is a common one in India. The Indian Museum possesses specimens from Sikkim, Sibsagar, Birbhum, Murshedabad, Sahibganj, Calcutta, and Malda. It belongs to a family of leaf-feeding beetles, so any damage that it may do will no doubt be of the nature of defoliation. Nothing seems to have been recorded in India upon the subject of its transformations. From what is known of other species of the same family, it may be expected that the eggs are laid upon the leaves, that the larvæ are active little creatures which feed upon the foliage, eventually transforming, in some sheltered corner, into stationary pupæ from which the beetles ultimately emerge. These points, however, require corroboration. It would be useful also to ascertain the period spent by the insect in its various stages of development at different times of the

year, the number of annual generations, and the plants other than tea which it attacks.

CURCULIONIDÆ.

Astycus chrysochlorus, Wied. This beetle was sent to the Indian Museum in April 1892 from a tea garden in Cachar, where it was supposed to have been the cause of some injury to the bushes.

It was said to strip the young leaves off the tea shoots, but nothing further is known of its habits. The block shows the beetle, natural size, with enlarged figure of its antenna. The insect is covered with tiny scales, which give it a light greenish lustre.

LEPIDOPTERA.

COSSIDÆ.

Zeuzera coffeæ, Nietner—(Red borer[1]). The larva of this moth is a reddish grub, which tunnels into the stems not only of tea bushes, but also of coffee bushes and young sandalwood trees.

[1] White borer of Hampson.

The figure shows the moth and pupa, also a little piece of stem containing a full-grown caterpillar, and an empty pupal case protruding from the tunnel, as it appears after the moth has emerged. The specimens from which the figures are taken were reared in the Indian Museum from infested sandalwood stems from Mysore.

Caterpillars thought to belong to the same species have been sent to the Museum from tea gardens both in Darjiling and in Jorhat.

The insect was originally described in connection with coffee by Nietner in his pamphlet on the enemies of the coffee tree in Ceylon, 1861. The following is an extract from S. Green's edition of Nietner's work, page 14 (Colombo, 1880) :—

"This insect . . . . destroys many trees, young and old, the caterpillar eating out the heart: for this purpose it generally enters the tree six or twelve inches from the ground, ascending upwards. Fortunately it is not abundant. It resembles the caterpillar of the goat-moth of England, is two inches long, and as thick as a goose-quill, nearly naked, of yellowish colour, back red, head thoracic, and anal plates blackish; when full-grown the colours are light and dirty. The sickly, drooping foliage, and a heap of globules of conglomerated wood-dust at the foot of a tree soon indicate that the caterpillar is carrying on its destructive work inside. The chrysalis rests three months, and its skin half protrudes from the hole when the moth escapes, which is about February. The moth measures 1¾" across the wings, which are white, spotted with steel blue; the upper ones, with one large spot and numerous series of small ones, placed in rows between the nerves; the lower wings are less spotted. Thorax with four spots near margin. Abdomen variegated with blue. Legs blue, second pair with white femora, third pair with white femora and tibiæ."

An excellent account of the insect in connection with tea has lately been given in a paper by Mr. E. E. Green, which appeared in the *Ceylon Independent*. According to Mr. Green's observations it is by no means uncommon on tea estates in Ceylon, though the damage which it does is often ascribed to other causes, as the caterpillar is very completely concealed in the interior of the stem. The female moth lays her eggs in the bark, and the young caterpillars tunnel their way into the heart of the wood. They are generally found in the first instance in the smaller twigs, but as they grow bigger they make their way into the main branches and stem, and sometimes kill young tea bushes down to the ground. When full grown they transform into chrysalids in the burrow. Mr. Green adds that the presence of the insect may usually be detected by the heaps of sawdust-like excrement to be found on the ground under the bush.

The chief points which remain to be ascertained in connection with the life-history of the insect are the dates of emergence and the periods of time spent by it in the egg and larval stages. In the case of coffee Mr. Nietner observed that the moth emerges about February, and it is noticeable that a moth reared in the Indian Museum in 1892 from sandalwood, forwarded to Calcutta from Mysore, also emerged in this

mouth. Mr. Green, however, notices that he has found moths at several other times of the year in Ceylon, so it would appear that the insect does not invariably emerge in February. The European species *Cossus ligniperda*, Fabr., which belongs to the same family, is said to spend as much as three years in the larval stage, and it is not unlikely that *Zeuzera coffeæ* will prove to be nearly equally slow in development, though, as a general rule, insects develop more rapidly in India than in Europe.

With regard to remedies, cutting out infested stems seems to be the most promising treatment that has been suggested, though the damage occasioned appears to be seldom sufficient to make this worth while. In the case of coffee bushes Dr. Bidie remarks (*Report on the ravages of the borer in coffee estates*, Madras, 1867):—"If not much injured, the external opening should be closed with a wooden peg, which causes the death of the borer, and the tree will then in all probability recover." Squirting kerosine oil into the hole or hooking the grub out with a barbed wire would also be likely to be effective in cases where the trouble was worth taking.

Notodontidæ.

Lobster caterpillars.

Stauropus alternus, Walker. The caterpillar of this species has been recorded by Green as occasionally feeding on the leaves of the tea plant in Ceylon. It has also been noticed as feeding on cocoa and *Cassia fistula*. As in the case of other members of the same family, the caterpillars are curious hump-backed creatures with long legs. Pamber notices that they are found in Darjiling, and as the species is one that occurs throughout India, besides inhabiting Ceylon, it may appropriately be included in the present report.

The figure, which is after Moore, shows the moth, larva, and cocoon, all natural size.

The caterpillar spins a cocoon amongst the leaves, and Green records that the pupal stage lasts for two or three weeks. The eggs are likely to be laid upon the tea plant, but neither the locality of ovi-position nor the number of generations in the year seems as yet to have been ascertained.

Limacodidæ.

Limacodidæ caterpillars (nettle grubs) have been reported as attacking tea alike in the Dooars, Assam, and Ceylon. They feed upon the foliage and can be recognised by their curious slug-like appearance. They are mostly brightly coloured and armed with urticating spines which are capable of inflicting an unpleasant sting. When full grown, the caterpillar forms around itself a curious potato-like case which is a very characteristic feature of the family. Here it transforms into a chrysalis, from which, after a period of repose, the moth emerges. The species hithereto recorded as attacking the tea plant are as follows:—

(1) Thosea (Miresa) cotesi, Swinhoe. Pupal cases very similar to those of this species, but insufficient for precise identification, were sent to the Indian Museum in October 1889 from a tea garden in the Dooars where they had been found upon tea bushes.

The species itself was afterwards described by Colonel Swinhoe from

moths reared in the Indian Museum from caterpillars forwarded from Durrang in January 1891. In Durrang the caterpillars were reported as having defoliated tea bushes and when full grown descended to the ground to pupate. Children had been employed to hand-pick the caterpillars, but the insect had proved too numerous to be dealt with successfully in this way. Some difficulty also was experienced in hand-picking owing to the stinging spines with which the caterpillars were armed.

The figure shows the male, female moths, also the empty pupal case, all natural size, drawn from specimens reared in the Indian Museum. The pupal case is depicted with the upper portion pushed up, like an open lid, as it appears after the moth has emerged.

With regard to the times of emergence, all that has yet been observed is as follows:—Full-grown caterpillars, sent to the Indian Museum from Durrang in January, transformed into pupæ the same month, moths emerging on 26th January. From its activity in the coldest month of the year and the short period spent in the pupal stage, the insect would seem likely to pass through a number of generations in the year, but more extended observations are required.

Parasa lepida, Moore. This species has been recorded by Green as attacking tea in Ceylon. It has previously been noticed, under the name *Limacodes graciosa,* by Nietner as defoliating coffee bushes in the same island. It has also been reared in the Indian Museum from caterpillars found feeding upon mulberry leaves in Calcutta. The Museum further possesses specimens from Ranchi. The insect has also been recorded from Java, so is probably widely distributed.

In the case of the specimens reared in the Indian Museum, the caterpillars were found in September, but the moth did not emerge until June in the following year, the intervening eight months being spent in the pupal case. This long period of hybernation does not appear to be an invariable feature of the life-history of the species, for Nietner, writing in connection with Ceylon, observes "the chrysalis rests from

the middle of August to the middle of October." A probable supposition is that the insect passes through several generations in the year, the length of time spent in the chrysalis stage being liable to protraction when warmth or moisture, or both, are deficient.

The fact that Nietner only records the presence of the caterpillars upon Ceylon coffee bushes between the months of June and August points to the possibility of at least occasional hybernation even in that island.

The figure above, which is after Moore, represents the male and female moth, also the caterpillar, all natural size. The moths are brownish in colour with bright green markings. The caterpillar is greenish with mauve stripes; the sting which its spines are capable of inflicting is described by Green as rather more intense than that of the common nettle. The cocoon is purplish in colour and is usually attached to the plant. Green describes the eggs as oval and almost transparent; he found them in masses of from fifteen to twenty on the back of the leaf, overlapping each other like the scales of a fish.

Psychidæ—(*Bag worms*).

Several species of Psychidæ attack tea. The caterpillars, which are popularly known as "bag worms," may be recognised by the curious little cases of sticks or leaves which they carry about upon their backs. They injure the tea plant by eating up the foliage. The caterpillar enlarges its case from time to time as it grows bigger. When full grown it fastens its case with silken strands on to some twig or leaf. It then closes up the entrance in front and, after turning completely round upon itself inside the case, so that its head comes where its tail had previously lain, it moults its skin for the last time and transforms into a pupa (=chrysalis). After resting for a while, the pupa, which is armed

with curious backward set spines for the purpose, works for itself an opening in the loose end of the case. The pupal skin then cracks and the sexually mature insect emerges. The female is a degraded wingless grub which never quits the case. The male is an active winged moth which flies rapidly about and mates with the female as she lies inside the case. After mating, the male dies and the female proceeds to lay her numerous eggs inside the case.

The treatment that seems to be generally adopted upon tea gardens is that of collecting the cases by hand. As the eggs are laid inside the case, it is necessary to collect not only those which have caterpillars inside them, but also the old and apparently dead cases; for otherwise there will be fear of leaving cases full of live eggs from which young caterpillars may afterwards emerge in great numbers. As the female is incapable of flight, the only way that the insect spreads is by the caterpillars, which are very active, crawling from bush to bush. The evil, therefore, can easily be kept in check by a vigilance in picking off the caterpillars.

A small trench with a streak of coal-tar at the bottom is likely to be sufficient to prevent the insects from invading a garden from the neighbouring jungle. This they are always liable to do, for most of the species feed upon numerous other plants besides tea. The species hitherto recorded as attacking tea are as follows:—

Eumeta crameri, Westw. Caterpillars of this species have been sent to the Indian Museum on several occasions from tea gardens alike in Sikkim and Assam.

The insect has also been recorded by Green as feeding upon both tea and coffee bushes in Ceylon.

The cases, shown natural size in the figure, are like miniature fagots of sticks. The most remarkable feature about the caterpillars is their extraordinary vitality. Indeed, they will withstand an amount of rough handling which would be fatal to the larvæ of almost any other group of Lepidoptera. The point is an important one to remember in considering how best to dispose of what are brought in by coolies.

The chief points in connection with the insect which remain to be ascertained are the number of generations in the year and the periods passed in the various stages of development.

Eumeta sikkima, Moore. A very complete and interesting account of this insect has been given in the pages of *Indian Museum Notes* by Mr. G. C. Dudgeon, who found the caterpillars very generally upon sâl and less often upon tea in the Darjiling district.

The figure, which has been taken from specimens presented to the Indian Museum by Mr. Dudgeon, shows:—(1) the male moth; (2) the degraded wingless female as she appears when taken out of the case; (3) the larval case in which the female passes her existence; (4) the larval case of the male, with pupal skin protruding from which the male moth has emerged. The figures are all natural size.

The following is an extract from Mr. Dudgeon's paper:—

"The larvæ emerge about the 1st of April from eggs laid at the beginning of March in the same year. This is the first brood of the year, but the others do not follow in any regularity, and it has been impossible for me to ascertain how many broods there are, as the larvæ and pupæ are found in all stages throughout the rains. Larvæ when first emerged are about one-sixteenth of an inch in length. Colour

reddish brown. Heads large, mandibles strong. Body cylindrical, tapering towards the tail end. Pectoral legs large, long, and very powerful; abdominal legs seen perfectly through magnifying glass, semi-developed, ten in number, including anal legs. Pectoral segments dorsally covered with a light brown shell-like covering. They do not seem to utilise the old cocoon in the construction of their own cases, and walk about for days with the abdominal segments always held perpendicular to the rest of the body. Some form cases about the third or fourth day from bits of moss and bark of sâl trees on the leaves of which they feed, but they constantly desert their cases at first. The larva feeds on the young leaves of the trees at this stage, but afterwards seems almost to prefer the old and tough ones. The larva never leaves its case after it has once begun to enlarge it, which it does by adding small bits of moss, leaves, flowers, stalks, and in one case the elytra of a beetle was used. The mouth of the case is always made flexible, so that when alarmed the insect can draw in its head and the mouth of its case as well."

Cases of a Psychid, which may perhaps belong to the same species, were sent to the Museum in 1888 from Ranchi, where they were said to appear chiefly in November and to infest tea, sâl, and other plants. The material in this case was insufficient for the absolute identification of the species.

Amatissa consorta, Templ. This insect was sent to the Museum as responsible for a good deal of damage to tea in the Darjiling district in the early part of the rains of 1893.

The specimens received in June were larvæ, but both males and

females emerged in the Museum before the rainy season was far advanced, so the period passed in the pupal stage must be comparatively short.

Several specimens of an Ichneumonid parasite, also a single Tachinid parasite, emerged in the rearing-cage in which the caterpillars were kept in the Museum. These parasites have not yet been precisely determined, but they both belong to groups of insects which lay their eggs upon caterpillars. From what has been observed in the case of other species we know that the grubs which emerge from these eggs cut their way into the caterpillar's body. Their victim may drag on a weary existence for some time afterwards, but invariably perishes in the end, without leaving offspring. The point is interesting as it shows that even the tough case in which the bag worm encloses itself is not sufficient to ensure it from the attack of these parasite forms, which, as will be shown under the heading of *Dasychira thwaitesii*, have a wonderful effect in keeping down some defoliating species of Lepidoptera in India.

The block shows—(1) Adult male of *Amatissa consorta;* (2) its larval case with empty pupal skin protruding; (3) Tachinid parasite; (4) Ichneumonid parasite.

The figures are all drawn natural size.

Govisana bipars, Walker. An insect thought to belong to this species has been recorded by Dudgeon as feeding upon the tea plant in Darjiling. Dudgeon noticed that it completely strips the tea bushes it feeds on, and often kills them by taking off the bark to make its case. The figure is from a specimen of the male moth presented to the Indian Museum by Mr. Dudgeon.

Postscript.—A quantity of live caterpillar in various stages of development, which are thought to belong to the species *Govisana bipars*, Walker, have just been received from a tea garden in Assam where they are said to have killed a number of bushes down to the ground by eating off the bark—28th March 1894.

Babula sp. Bamber notices a caterpillar of this genus which "builds for itself a conical case from the epidermis of the leaves on which it lives." He adds—"I have only seen it on a few bushes in Assam, but these it completely defoliated, being present on the bushes throughout the whole season and preventing their flushing." The insect

may not improbably belong to the species *Babula grotei*, Moore (=*Acanthopsyche moorei*, Hampson), figured below.

The figure to the left represents the male moth, that to the right its larval case with empty pupal skin protruding. The figures are taken from specimens reared upon *Lagerstræmia indica* leaves in the Indian Museum. The species has also been recorded as feeding upon babul.

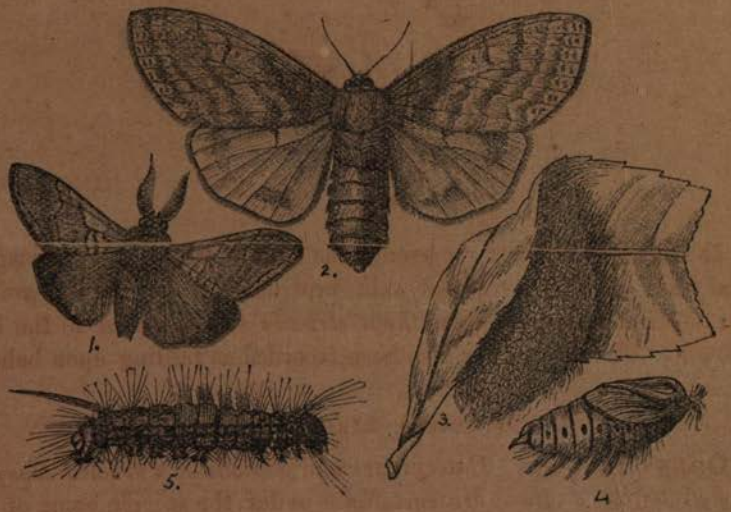
BOMBYCES, VARIOUS FAMILIES.

Dasychira sp. Caterpillars and cocoons of a species *Dasychira*, referred to in *Indian Museum Notes* under the specific name of *Dasychira thwaitesii*, Moore, were sent to the Indian Museum in February 1886 from a tea garden in the Dooars where they were said to have caused serious damage by feeding upon the leaves. The insect is thought to be identical with a species previously recorded by Fisher as having defoliated a large area of sâl trees in the Dooars in October 1878, where it also attacked tea and other plants.[1]

The caterpillar is covered with hair and has four thick tufts on the back which give it a somewhat characteristic appearance. When full grown it spins itself up between the leaves of the tea plant in a scanty cocoon composed chiefly of its own hair, which appears to be very easily detached. Here it transforms into a chrysalis. In the case of the February generation, which was the one kept under observation in the Indian Museum, the insect remained in the cocoon for rather less than a

[1] See *Indian Museum Notes*, Vol. I, p. 29.

fortnight. The number of generations in the year and the time spent in each of them has not yet been ascertained.



The figure above shows—(1) the male moth; (2) the female moth; (3) the cocoon partially enveloped in a tea leaf; (4) the chrysalis as it appears when extracted from the cocoon; (5) the caterpillar;—all natural size.

The most remarkable feature noticed about the insect was the extent to which it suffered from parasites. The number of live caterpillars and cocoons forwarded to the Museum was considerable, but so great was the mortality among them from this cause that very few moths could be reared. On the other hand, large numbers of Tachinid flies emerged in the breeding-cage, also two species of Chalcidæ. The Tachinid flies have been referred to the two species *Trycolyga bombycis*, Becher, and *Masicera dasychiræ*,[1] Wulp. The Chalcidæ have been identified as *Chalcis euplœa*, Westw., and *Perilampus sp.*

Both the Tachinid flies and also *Chalcis euplœa* are practically certain to attack the caterpillar. In the case of the *Perilampus* there is some doubt; indeed, from observations made by Howard in America upon other species of the same genus, it is probable that the insect is parasitic, not upon the caterpillar, but upon the Tachinæ. The question of the habits

[1] Of the four adult specimens preserved in the Indian Museum, three appear to belong to the species *Trycolyga bombycis*, Becher, and one to the species *Masicera dzsychiræ*, Wulp.

of the *Perilampus* is an interesting one, though the insect has not yet been found in sufficient numbers to be of any practical importance.

The wood-cut to the left shows *Chalcis euplœa* enlarged; that to the right shows the *Perilampus*, also enlarged. The natural size in each case is indicated by hair lines.

The most important parasites are undoubtedly the Tachinid flies, which would seem to act as a most effectual natural check upon the multiplication of this and other defoliating caterpillars in India. Their history requires very careful working out, as there are two forms concerned which superficially are almost indistinguishable from each other, though the specialist in Holland, to whom they have been submitted, looks upon them as representing separate species. The point is an important one to investigate, as one of the two species (*viz.*, *Trycolyga bombycis*, Becher) is the well-known silk-worm fly which is very destructive to silk-worms in Murshedabad and elsewhere in Bengal.

The figure above shows *Trycolyga bombycis* on three stages of development, all natural size. To the left is the full-grown larva (maggot), in the middle is the pupal case, and to the right is the sexually mature fly. The habits of *Trycolyga bombycis*, as observed in the silk districts,[1] are briefly as follows :—The fly lays its eggs, one at a time, on the bodies of the caterpillars. One fly is therefore able to infect a large number of caterpillars. The egg hatches a few hours after it is laid, and out of it creeps a tiny maggot which bores its way into the body of the caterpillar. Here it lives and grows, feeding on the fatty tissues of its host

[1] See *Indian Museum Notes*, Vol. I, p. 83.

for about a week. The caterpillar in the meantime lives on and may even spin itself up into a cocoon. When full grown, the maggot, which now looks much like a grain of boiled rice, endowed with movement, cuts its way out of the caterpillar's body and crawls down to the ground, where it buries itself. In cutting its way out of the caterpillar's body it inflicts such severe injury that the caterpillar invariably dies. In the ground the maggot transforms into a pupa enclosed in the brown bean-shaped case shown in the figure. In this state, in warm weather, it remains inactive for about a fortnight, the pupal case then cracks and out of it emerges a full-grown winged fly which seeks a mate and becomes in a few days the parent of another generation. The period spent in the different stages of growth varies according to the time of year, the pupal stage in particular being said to be protracted, in the cold weather, to some months, during which period the insect hybernates.

Suggestions have been made for importing the silk-worm fly from the silk districts, in cases where defoliating caterpillars have multiplied excessively, and the experiment would seem to be well worth trying, though its success must depend largely upon the question, which has not yet been sufficiently investigated, of the relative importance of the part played by this particular species amongst the numerous forms which attack caterpillars in India. From recent observations, now in course of publication in the periodical *Indian Museum Notes*, it appears that *Trycolyga bombycis* attacks such different caterpillars as the mulberry silk-worm, the eri silk-worm, the tea *Dasychira*, and *Olene mendosa*, Hübn. In the case of the mulberry silk-worm, we know that a very few flies, when allowed unimpeded access, are able rapidly to destroy a very large number of caterpillars. Indeed, so much is this the case that the doors and windows in Bengal silk-rearing establishments have to be carefully protected by screens in order to keep out the flies. Where this precaution is not taken, the silk-worms are liable to be destroyed almost wholesale. Mukerji recounts how, upon one occasion, the fly destroyed ninety per cent. of a lot of silk caterpillars he was rearing in Berhampore, and his experience is a common one. It remains to be seen to what extent it can be turned to practical account.

Chalcis euplœa is likely to attack the caterpillar in a manner very similar to that adopted by *Trycolyga bombycis*, the only point of much practical importance in which it is likely to differ, being in the place of pupation, for Chalcidæ larvæ often pupate in, or close to, the body of their victim, instead of sheltering themselves in the ground as is the case with Tachinæ. The precise habits in this instance have yet to be ascertained by actual observation.

Olene mendosa, Hübn.—(=*Dasychira mendosa*, Hamp.) Caterpillars of this species were sent to the Museum in February 1890 from

Darjiling, where they were said to feed upon tea bushes. The figure shows the female moth, also the caterpillar, both natural size.

The figure of the moth is from a specimen reared in the Indian Museum, that of the caterpillar is after Moore. The male moth is a brownish creature not unlike the female, but differs in being very considerably smaller and in having pectinated antennæ. The caterpillar is covered with hair. One of the specimens sent to the Museum was found to be parasitized by the Tachinid *Trycolyga bombycis*, Becher. No further information has been obtained, but the insect is likely to have very similar habits to the *Dasychira sp.* described above.

Undetermined hair-covered caterpillar. The precise identity of this insect has not yet been ascertained. The following extract from a note by the writer (*Indian Museum Notes*, Vol. III, page 2) gives all that has yet been recorded about it:—

"In April 1891 specimens were furnished by Messrs. Andrew Yule & Co. of an insect which had proved destructive to tea (*Camellia theifera*) in the Jorhat district of Assam. The manager of one of the gardens wrote that he had been getting twenty-five 2-maund bags of these caterpillars picked off the bushes daily, but that in spite of all his efforts they seemed rather to increase in numbers. They stripped the leaves and the bark of the bushes to such an extent as in some cases to kill the plants. The manager added that during the ten years he had been in the district he had never seen such a visitation, and that his coolie sirdars, some of whom had been over twenty years on the garden, could not remember the like. The specimens that were forwarded were found to be the larvæ of a Bombyces moth which is thought to belong to the family Arctiidæ. The insect does not appear to have been previously sent to the Museum as attacking tea, and it cannot be identified precisely without an examination of the moth into which the caterpillar transforms."

Andraca trilochoides, Moore. The caterpillars of this species (= *A. bipunctata*, Hampson) were reported in 1893 as doing a good deal of damage by defoliating tea bushes both in Cachar and Jorhat. The

figure shows the moth, the catterpillar and the cocoon, all natural size from specimens forwarded to the Indian Museum :—

The first specimens that reached the Indian Museum were forwarded from Cachar in January 1893. The insect continued prevalent in Cachar for some time subsequent to this date, and was again sent to the Museum in September 1893 from Jorhat. In Cachar, according to the information forwarded, the bushes that were attacked were not situated in blocks, but were scattered here and there through the tea. In many cases they were said to have been completely defoliated, and the nature of the damage that was occasioned may be judged from the fact that in one garden alone in Cachar, in the six months ending May 1893, it was found worth while to spend some fifteen hundred rupees in employing coolies to pick the insects off the bushes. In this case no less than sixty-nine and a half maunds weight of caterpillars were said to have been destroyed—a goodly quantity when it is remembered how voracious is the appetite of each individual insect.

Moths emerged in the Museum in March and from caterpillars received in February from Cachar. From caterpillars again, forwarded to the Museum from Jorhat in September, moths emerged in October. This would seem to indicate that development goes on throughout both the rainy season and the cold weather, the number of generations in the year being, no doubt, numerous. The cocoon is a loose silken structure attached to the twigs of the tea plant, so in habits the insect is likely to resemble the *Dasychira* described above.

Geometres.

In July 1890 an obscure Geometrid caterpillar was forwarded to the Indian Museum from Nowgong, Assam, where it was said to have been attacking tea bushes. The material furnished was insufficient for the precise identification of the species, and as the insect has not

subsequently been complained of, it is not likely to be of very much importance.

The figure shows the caterpillar, natural size. The specimen was kept for some time in alcohol before the drawing was made, so the figure is not a very satisfactory one, though it gives the essential features of the insect.

Caterpillars of the group Geometres can be recognised by their peculiar mode of progression. They have the anterior pairs of prolegs rudimentary and the remainder set far back, while the body is slender and elongated. Owing to this peculiar structure they are able to step along with considerable rapidity, by holding the ground first with the little jointed legs (A), at the front end of the body and then with the prolegs (B), at the posterior end, while they alternately hump up their bodies and stretch them out to their full extent. Geometres caterpillars are on this account popularly known as loopers. They all feed upon leaves. When full grown, the caterpillar transforms into a chrysalid whence the moth afterwards emerges. The moths of the various species are very different from each other in appearance, but most of them are slender creatures with large weak wings. The males have flat comb-shaped antennæ, the females have slender thread-like antennæ. The species which feeds upon tea has yet to be determined and traced through the various stages of its development.

NOCTUES.

Agrotis suffusa, Fabr. This cosmopolitan insect is one of a number of allied species which do much damage to crops in all parts of the world.

It has been recorded by Green as attacking young tea plants in Ceylon, where its caterpillar is known as "black grub." It has not actually been sent to the Indian Museum in this connection from any Indian tea garden, but it has frequently been reared by the writer from caterpillars sent to the Museum as attacking other crops in India, and it represents a group of insects with one or more of which the Indian tea planter is very likely to be troubled. It has been reported as attacking various crop plants in Kurseong, Jessore, Murshidabad, Tipperah, Ghazipur,

Fatehgarh and Behar, and as specimens have also been captured by entomologists in Kulu, Solun, Sikkim, Calcutta, Mhow, Poona, and Quetta there can be no doubt about its prevalence throughout India.

The figure shows the moth, and the full-grown caterpillar, both natural size, the former from a specimen in the Indian Museum, the latter after Riley. The caterpillar is a soft dark-coloured grub which lives in a hole in the ground in the day-time and sallies out at night to feed upon young plants which it bites off close to the ground.

Green notices that a single caterpillar will sometimes cut off as many as twelve young tea plants in one night, the severed stems being left lying about where they fall. It will thus be seen that the insect is capable of doing a good deal of damage.

Like other "cut worms" the caterpillar of *Agrotis suffusa*, when full grown, transforms into a chrysalis in the ground. From this chrysalis the moth afterwards emerges ready to mate and lays its eggs. The insect has been very carefully studied in America by Dr. C. V. Riley, United States Entomologist, who writes in one of his reports :—

"The eggs are laid in small batches, and often in two or three layers, covered sparsely with long scales from the abdomen of the female moth. They are pale-fulvous in colour, and nearly spherical in shape, the base being somewhat flattened. The polar ribs are not very distinct, and the crown is small. These eggs we have found laid on peach and sycamore leaves, upon which the larvæ do not feed. The larva in the first stage is also a semi-looper, the front prolegs being atrophied. The species is parasitized by Tachinidæ, which we have often bred from it."

In Behar opium fields the caterpillar has been reported as chiefly prevalent between November and March, the moth being common from the beginning of February until the beginning of March. A caterpillar, forwarded to the Indian Museum in May 1889 from Kurseong, transformed into a pupa on 17th May and emerged as a moth on 28th May. A moth again emerged in one of the Museum rearing-cages

in March 1890 from caterpillars forwarded from Oudh the same year. The Museum also possesses a moth from Jessore dated September. It may be concluded that in Northern India the insect goes through several generations in the course of the year. The precise habits in this respect, however, have yet to be observed in connection with tea.

Digging the caterpillars out by hand or flooding them out of their burrows with water and then collecting them seem to be the most satisfactory methods of dealing with the pest.

According to Scott, who observed the insect in poppy-fields in Behar between the years 1874 and 1878, the cultivator goes round his poppy-plot in the morning, armed with a spade, with which he digs out the caterpillar wherever he sees the protruding leaves and stalks which mark the creature's burrow. Irrigation also is employed to bring the caterpillars to the surface, where they are fed upon by crows, mynas, starlings, cattle egrets and other birds, though these creatures are not sufficient by themselves to keep down the number of the insect. Scott adds that the pest can easily be checked by dusting the plants over a few times in the evenings with a mixture of quicklime and ashes, but he notices that the cultivators generally do not resort to this method.

Achæa melicerte, Drury. The caterpillar of this moth was reported from Dehra Dun in August 1892 as doing some damage to tea. It first appeared in the early part of the rainy season on the tallow tree (*Sapium sebiferum*), and seems only to have attacked the tea plant to save itself from starvation after all the leaves on the tallow trees had been devoured.

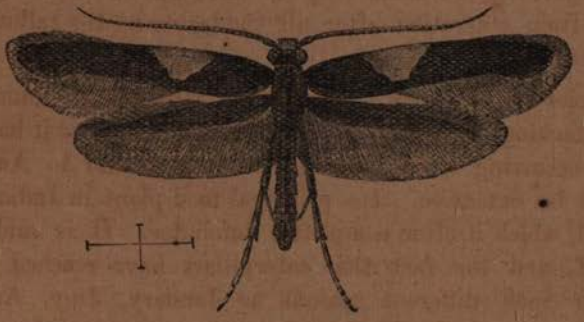
The species has been sent to the Indian Museum on numerous occasions as attacking a variety of crops in India, and as it has also been recorded as occurring in the Malay Archipelago and in Australia, its range must be extensive. Its principal food plant in India appears to be castor oil, which it often completely defoliates. It is said to pupate in the leaf, and the fact that caterpillars have reached the Indian Museum in such different seasons as January, July, August, and September, makes it likely that a number of generations are gone through in the course of the year. In the rainy season in Dehra Dun

the caterpillar stage was said to have occupied from fifteen to twenty days, while about ten days were spent in the pupal stage.

The figure shows the moth and caterpillar, both natural size.

MICROLEPIDOPTERA.

Gracilaria theivora, Wlsm. This species was originally described by Lord Walsingham in the pages of *Indian Museum Notes* from specimens furnished to the Indian Museum by Mr. E. E. Green, who reared them from caterpillars which he found mining the leaves of the tea plant in Ceylon.



The figure, which is after Walsingham, shows the moth much enlarged. The natural size is indicated by hair lines. The insect is not known to do any appreciable damage in Ceylon, and has not yet been recorded from India.

The following summary of its habits, as observed by Mr. Green, is reproduced from *Indian Museum Notes,* Vol. II, page 50 :—

"The egg is laid on the underside of a young leaf, generally on a young bush. On the hatching of the egg, the young caterpillar mines the leaf, the mine being visible on the underside only and terminating in a small pocket formed by the folding over of the edge of the leaf. Here the caterpillar sheds its skin, and, this done, it proceeds to roll

the leaf together, so as to form a shelter in which it lives for the remainder of its larval life, feeding upon the substance of the leaf." When full fed, it is about three-eighths of an inch in length, and yellowish or greenish in colour, with a few short bristles scattered over its body. The chrysalis is formed in a flat silken cocoon on the leaf, the pupal stage lasting about two weeks. The caterpillar is attacked by minute Ichneumonidæ, besides being often drowned in wet weather by the water that accumulates in the rolled-up leaf."

Pandemis (? Capua) menciana, Walker (=*Cacœcia sp.*, Green). The caterpillar of this minute moth has been recorded by Green as doing a good deal of damage in Ceylon tea gardens. It has not yet been authoritatively recorded from India, but Bamber notices the presence of an insect which may perhaps belong to the same species.

According to Green's observations, as published in the *Ceylon Independent*, the caterpillar, which is a yellowish creature, when full grown about three quarters of an inch in length, feeds upon the young leaves. It twists up the leaves and spins them together with a silken web, thus rendering the shoots unsuitable for tea-making. When full grown, the caterpillar transforms into a chrysalis in a silken shelter which it spins for itself between two leaves. From the chrysalis emerges a minute brownish moth with the bell-shaped wings characteristic of the group Tortrices.

DIPTERA.

Oscinis theæ, Bigot, MS.—(=*Agromyza* (?) *sp.*, Green). This minute two-winged fly was discovered by Mr. E. E. Green, who traced it through its various stages of development in Ceylon, where its larva mines the leaf of the tea bush. It is not known to have done any appreciable damage in Ceylon and has not yet been recorded from India.

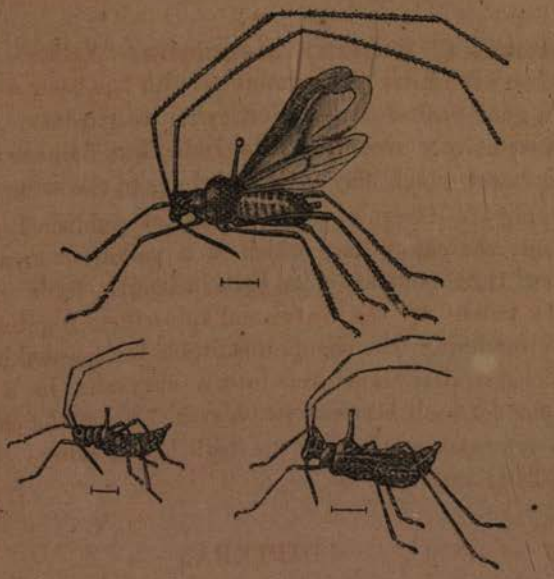
According to Mr. Green's observations, as recorded in the pages of the *Ceylon Independent*, the egg is laid upon the leaf. The larva, a minute yellowish maggot, burrows into the tissue of the leaf, leaving a sinuous tunnel easily visible from the exterior. When full grown, it pupates at the end of its tunnel, and emerges after a few days in the form of the adult fly. Mr. Green notices that the insect is subject to the attack of a minute hymenopterous parasite.

RHYNCHOTA.

Capsidæ.

Helopeltis theivora, Waterhouse—(=*H. theivora*, Moore, as quoted by Wood-Mason). This insect does a great deal of damgae to tea. It chiefly attacks the tender leaves which are the ones used in tea-making, and as it affects wide areas, it is a formidable enemy to the tea trade. When full grown, it has much superficial resemblance to the

mosquito, and is hence generally known as "Mosquito blight." It may be distinguished at a glance by its knobbed scutellar spine which has been appropriately compared to a minute drumstick sticking out from the middle of its back.



The figures, which are taken from specimens in the Indian Museum collection from Assam, show the larva in two stages of development, also the winged form, all much enlarged. The natural size in each case is indicated by hair lines.

Attention was first directed to the insect by Mr. S. E. Peal, who published a valuable paper upon it in the Journal of the Agricultural and Horticultural Society of India (Vol. IV, 1873), with excellent figures, illustrating both the various stages of the insect after leaving the egg, and also the damage done by it to the tea bush. The method of oviposition was first described by the late Mr. J. Wood-Mason, whose report appeared in 1884. Further light upon the habits of the insect is afforded by some valuable communication to *Indian Museum Notes* from Messrs. Harcourt and Dudgeon; while for information relating to the practical side of the question, the writer is also indebted to a review of the genus Helopeltis by the late Mr. E. T. Atkinson.

The nature of the damage.

The insect injures the tea bush by sucking up the juice with its proboscis, which it inserts into tissue of the leaf much in the way that the mosquito sucks blood. The following extract from Peal's paper, as quoted in

Wood-Mason's report, gives an excellent account of the nature of the damage in Assam:—

"The general view of the tea is that the shoots are all brown, withered, and in fact dead, and the tea presents a generally brown look, instead of the bright healthy green that is usual.

"On examining a tree so affected, if the blight has only recently affected it, the appearance is very different from that of a tree which has suffered some time. In the former case, the general growth and the look is normal, but the youngest shoots and tips are more or less spotted with brown, the size of the spots varying with the age of the insect. If the bug is very young, the punctures are close and minute, and the discolorations coalescent; but if it is full grown, the spots are larger, say an eighth of an inch in diameter. Again, if the punctures are recent, the colour is pale brown and darkest at the edges; but if one or two or more days old, the spots are dark brown verging on black, the entire leaf curling up and withering completely if they are close.

"In the case of a tree that has suffered some time and severely, the symptoms are often less visible at first glance; the dead leaves have mostly fallen off, and the minute shoots at the leaf-axils alone show the damage, and all are dry and dead; there is less dead leaf showing, and in its place we find dead 'tips' everywhere.

"A more careful study will often show a still more unpleasant fact—*i.e.*, that ere it ceased entirely to shoot out, the tree had made many efforts to grow, all of which had been rendered abortive; and a branch that has not yielded one single leaf or tip will present all the appearance of having been very severely and persistently plucked.

"On the tips of the young vigorous shoot being punctured, it has died as certainly as if nipped off, and the eyes below in the leaf-axils shoot out vigorously; and ere the bug can do serious damage, one or two shoots have attained some size and carry several leaves; but as the insects increase in size, these tips again are attacked and other shoots start from other eyes, though attaining a less vigorous growth, and in a short time we have a regular 'broom,' where not one leaf or tip has been taken by us, but has been killed off or sucked dry by the bug alone: drawings of such I send herewith to illustrate. When this is the case, growth will have come to a complete standstill, as every shoot requires from (say) forty to fifty days to mature from an eye to be fit to pluck. We may say the trees are shut up for about two entire months at least; and it is specially unfortunate that this takes place usually about mid-season, and when we should be doing our very best. I do not state that the entire garden is thus affected at once, or we should soon see tea itself at a standstill, but that the particular patches and trees most blighted are so as before stated. It is difficult to tell what part will be attacked this year or next: all places seem pretty equally liable to blight, and, unless very bad indeed, it is seldom seen, as yet, over an entire garden at once; but that this will be the normal state eventually, I do not doubt. The recovery of the tree is slow, unless pruned, and then is about as bad as the disease, as far as our outturn of crop is concerned."

According to a summary of Harcourt's notes on mosquito blight in the Darjiling district, as given in *Indian Museum Notes*, Vol. II, p. 43, the blight does not ascend above an elevation of about 4,500 feet, and most of the damage is done in the Terai, tea planted on black sandy soil appearing to be particularly attacked. Gardens are often affected to the extent of closing the crop earlier than usual and considerably lessening the outturn.

The life-history of the insect.

Helopeltis theivora belongs to a group of insects which do not pass through an inactive pupal stage. According to Harcourt, the eggs are about

$\frac{1}{32}$ of an inch in length and very slender. When first laid, they are hard and white in colour, but they become red before hatching. The larva feeds like its parents upon the young tea-shoots, and Harcourt notices that it becomes full grown in about a week after emerging from the egg. Harcourt adds that it has the characteristic bug-like odour, and that the only animal he has noticed to attack it is a small spider. In his report referred to above, Wood-Mason describes the female as "provided with a serrated oviposition, of the shape and sharpness of a sabre, wherewith to pierce holes in the soft tissues of the plant for the reception of her eggs." He writes: –

"The female deposits her eggs singly in the substance of the tenderest shoots of the plant, in the *internodes* or portions of the stem between the pekoe and the two or three leaves succeeding from above downwards, and in the buds developed in the axiles of plucked leaves and in the parts thereabout . . . . the presence and position of each egg is from the first indicated on the exterior by two unequally long, glistening, white, bristle-like prolongations of the shell, and later by discoloration of the point pierced. . . . . The respiratory processes of the egg-shell so closely resemble the fine pubescence which clothes the surface of the shoots as to be quite indistinguished from it by the unaided eye, and, to eyes unaccustomed to zoological work, even with the aid of an ordinary lens. . . . . In order that the reader may form some idea of the number of the eggs, I may state that on one occasion I counted more than forty eggs in twelve shoots taken consecutively and at random from a plucker's basket, and that on another occasion I selected and plucked from one bush of a plot of tea, which was only moderately blighted, four shoots with one or more eggs in each. The females appear instinctively to avoid puncturing the shoots or the parts of the shoots in which they lay their eggs, for one can rarely find eggs on badly-injured shoots."

The method of oviposition has since been carefully observed by Dudgeon, who has worked independently in Darjiling. His results, as communicated to *Indian Museum Notes*, confirm in the main those quoted above from Wood-Mason, who worked in Assam, and show conclusively that little weight need be attached to the supposed discovery by less skilled observers of other methods of depositing the eggs.

The chief points which remain to be ascertained in connection with the life-history of the insect are the length of time passed in the various stages of development at different periods of the year, and the method of hybernation, also the extent to which plants other than tea are liable to harbour the insect.

In 1881, when Wood-Mason visited Assam, he found that the China variety of tea was alone attacked, the indigenous variety being untouched. He also reported that he had been unable to find the insect either upon the weeds of tea gardens or on the vegetation of uncleared and waste lands in the immediate vicinity. Dudgeon, again, has shown conclusively that an insect which attacks the shrub *Maesa indica* in Darjiling, is totally distinct from mosquito blight, though it is liable to be mistaken for the latter on account of the resemblance between

the marks left upon leaves by the two forms. Under these circumstances the reports which frequently appear of the finding of mosquito blight upon plants other than tea must be received with caution. It is worthy of note, however, that a species of *Helopeltis* so nearly allied to *Helopeltis theivora* as to have been considered, by so competent an observer as the late Mr. E. T. Atkinson, to be but a variety of this species, were forwarded to the Indian Museum in January 1888 from Munghu, Sikkim, where they had been found on cinchona. Again, the species *Helopeltis antonii*, Sign., which Wood-Mason notices is so closely allied to the Assam form as to have been considered by no less an authority than the late Professor Westwood to be only a variety of it, has been reported by Dr. Trimen as having "caused much alarm by its depredations on cacao and cinchona plantations" in Ceylon.[1] Under these circumstances the subject would seem to require further investigation, as it has an important bearing upon the question, which has not yet been satisfactorily settled, of what becomes of the insect when off the tea.

Remedies.

Owing to finding the eggs of the insect on the young shoots, Wood-Mason suggested the vigorous and unremitting plucking of the blighted portions of bushes as likely to mitigate the evil. This treatment would no doubt tend to be beneficial, but cannot be looked upon as complete in itself, for Dudgeon has since shown that the eggs are largely to be found upon the portion of the green shoot which is passed over by the leaf-pluckers as too hard for manufacture into tea.

The following account of what was actually done upon a tea garden in Dibrugarh is quoted from a report by the Manager, published, without date, as an appendix to Atkinson's paper in *Indian Museum Notes*, Vol. I, page 185 :—

"Now to reply to your inquiries about what we did to get rid of the 'Mosquitoes.' To begin with, before we stopped plucking last year, and while the blight was at its worst (about September and October), I started cutting down a 'belt' of jungle 80 yards wide all round the edge of the garden; this 'belt' was completed about the same time as the pruning of the garden was finished (the end of February this was): well, then I commenced lighting fires all over the place; in the tea the prunings were being reduced to ashes as rapidly as the cut-down jungle in the belt was being burnt up; by the middle of March I finished all the burning I wanted to do, and then every soul was put on to hoe round the bushes, *take away all stale earth from near the stumps of the plants, and fill in fresh earth.* The pruning I went in for last cold weather was most severe: the whole of the garden nearly was cut down to within eight inches of the ground; *all* knotty and gnarled wood was removed, and nothing but straight wood left. During the pruning, immediately following up the pruners were gangs of women and children armed with small knives whose only work was to rid the *bushes of every leaf and small twig.* To protect the plants from the flames (while the prunings were being

[1] *Vide Nature*, Vol. XXX, p. 634 (1884).

burnt) a drain fifteen inches deep by a foot wide was made in every alternate row of tea, and into this the pruning *leaves, &c.*, from round about were carefully brushed before being set alight to.

"Up to date not a trace of the blight is to be seen; this time last year about 100 acres (or more) were completely ruined; the tea is looking as healthy and nice, and growth is as vigorous as though the plants had never been blighted. So successful have we been so far in combating this destructive pest, that I am convinced now we will not be troubled with it *at all* this season, and that we will make our 8 to 8½ maunds an acre against a miserable 4 maunds an acre last season!

"The theory of letting tea run has been tried without the slightest signs of doing any good, for the simple reason the bushes *can't* and *won't* run! Bushes that I left alone during the three months (middle of April to middle of July) were, if anything, smaller at end of this period than at commencement of it, because not a vestige of growth had been made during the whole of this time, and the long healthy shoots (chiefly in the very centre, therefore the tallest part of the bush) died gradually down to the parent stem. I have measured some of these dead shoots occasionally and have found them in some cases to be over 18" long.

"The shoots that I have found to so die down have always been of this year's growth, *viz.*, those shooting out from just below last cold-weather pruning.

"Now, as blighted patches here have been found to have a large number of the young of the bug (which, by the bye, are in appearance like red ants, with two feelers apiece, and are wingless) in all stages of development (from the size of a pin's point to almost a full-grown bug) on nearly every bush, and as these young live right away inside the bushes and feed on only the 'minute shoots at the leaf-axiles,' the theory of pruning is to give the bush pruned a severe check and so stop for a time the rising of sap (and, of course, the production of the 'minute shoots at leaf-axiles') in the hopes this brief period of the bushes' dormancy will be sufficient to kill the young bugs of starvation. Whether we have succeeded or not in destroying *any* young ones by starvation it would be difficult to say, but that pruning is doing good is quite certain. Three days ago I got 25 maunds of leaf off the piece of tea that was pruned (5 acres in June last) in July; previous to pruning, this bit of tea was *completely* 'shut up' for about 2½ months.

"Of course we know it is only right to cultivate and keep extra clean any tea that may be 'hanging fire' or doing at all badly; I reversed the order of things with a bit of about five acres of very badly blighted tea: I allowed it to go into 'howling jungle,' the bushes were out of sight for over a month; strange to say, when I hoed and cleaned it up, after a fortnight, I found the bushes quite recovered and with a very decent flush on them. The block of tea of which these five acres are a part presents a peculiar spectacle with its small piece of bright green healthy tea surrounded by dismal-looking acres and acres.

"Some weeks ago I tried sprinkling kerosine and water (¼ of k. to ¾ of w.) over a piece (about 2 acres) of tea: on two occasions the day the mixture was squirted I found a young dead mosquito, evidently killed by the oil having reached them."

For accounts of other methods of dealing with the insects, reference should be made to Bamber's Hand-book, pages 247 and 248.

Helopeltis antonii, Sign. This species was originally described from Ceylon, where it was afterwards complained of as attacking both cacao and cinchona. It has since been referred to as attacking tea in Ceylon. It remains to be ascertained, however, to what extent the Helopeltis which is found upon Ceylon tea bushes is distinct from the insect referred to above under the name of *Helopeltis theivora.*

JASSIDÆ.

Chlorita flavescens, Fabr. (Green fly blight). A large amount of damage from this insect was reported in 1891 from tea gardens, especially in Cachar and in the Upper Assam Valley. Specimens reached the Indian Museum in the latter part of May from Assam, in June from Darjiling, and in July from Cachar.

In the case of the Upper Assam Valley, the insect is said to have appeared in the early part of the season and to have lasted on until June.

In no case do its habits seem to have been observed with any minuteness. It was generally supposed in the tea districts, however, to be responsible for the injury caused to the tea bushes, and as this was of a kind that it would be quite capable of inflicting, the probabilities are that it was rightly accused.

Both in life-history and method of feeding it is probably somewhat similar to *Helopeltis theivora*, though its eggs are more likely to be affixed to the leaf than buried in the tissue of the shoot. It may be noticed that the specimens forwarded to the Indian Museum in June from Cachar comprised both larvæ and adults.

The species is said to be fairly common in Europe and has also been recorded from Algeria, Brazil, and Siberia. It must necessarily, therefore, be able to subsist upon other plants besides tea.

The figure, which is taken from specimens in the Indian Museum collection from Cachar, shows the wingless larva when nearly full grown, also the winged adult. The figures are much enlarged, but the natural size of each form is indicated by hair lines, so no confusion need arise on this account.

According to a report dated 19th June 1891, from a garden in Cachar, as quoted in *Indian Museum Notes*, the insect stops the growth of the young shoots and prevents their ever becoming fit for plucking. The effect of the pest was said to be deplorable. Over whole sections of the tea garden the plants were covered with leaf about an inch in

length, which never grew any bigger; and one case is cited where 199½ acres had been plucked, and had given considerably less leaf than had often been obtained from a patch of seventeen acres. The only treatment that was tried was extra hoeing in the hope of bringing vigour to the bushes. The Manager adds :—

"To bring the state of things before you in the most comprehensive manner, I have pressed some shoots and send them by to-day's post, together with a little bottle containing about 100 of the insects which do, *or are supposed to do*, the damage. They are so active and difficult to catch that it took a boy a day and a half to procure the specimens to send. . . . . On one side of the sheet of paper, on which I have pasted the samples of shoots, you will find healthily-grown leaves, ... purposely chosen, rather under than over the average as regards size, so as not to create a false impression, or make the comparison too striking. On the opposite side of the sheet are thrippy shoots of all kinds, from the smallest to the largest, but also representing three leaves and the bud. Every one of these should have been as big or bigger than the healthy shoots, but I think the total weight of the sixteen former would not equal that of the three latter. A glance at the specimens will show you how impossible it is to make any outturn out of growth of this kind."

The shoots in question were forwarded to the Indian Museum through the courtesy of the Calcutta agents.

They are shown half size in the figure above. The sprig marked (*a*) is an ordinary healthy tea-shoot, while those marked (*b*) are shoots of the same age but suffering from the attack of the insect.

According to another report, also quoted in *Indian Museum Notes*, the experiment was tried upon one garden of placing open lamps about in the tea, in hopes of attracting the insects and enabling them to be destroyed. It was found, however, that whereas myriads of other insects

came to the lamps, the green fly remained undisturbed under the tea leaves.

In view of the fact that *Chlorita flavescens* is allied zoologically to a species which attacks mango blossom, and which from an experiment conducted in Saharunpore has been shown to be susceptible to an arsenical insect poison known to the trade as *London purple*, the writer of this report suggested in the pages of *Indian Museum Notes* that this preparation might be worth trying on tea bushes. It was pointed out that great care would be necessary in any application of *London purple* to tea on account of the poisonous nature of the substance; though in cases where a garden had been shut up by the blight there would be no danger in the experiment, provided no plucking at all were done until after a new flush had appeared and the bushes had been well washed by rain. Experiments were afterwards made with this and other insecticides by Mr. M. K. Bamber, who has published an interesting account of the result in his work on the *Chemistry and Agriculture of Tea*, pages 250 and 251. The matter would seem to be worthy of further investigation, though the results so far obtained have not been altogether promising.

FULGORIDÆ.

? Phromnia marginella, Oliv. Homopterous larvæ insufficient for precise determination, but thought to belong to this species, were forwarded to the Indian Museum in February 1890 from a tea garden in the Assam Dooars.

Very similar larvæ were sent to the Museum in October 1890 from a tea garden in the Mungledye District, Assam, with the information that they were feeding on the bushes and retarding the flushes, the whole garden being badly attacked.

Unfortunately the specimens from Mungledye cannot now be found. In recording the matter in *Indian Museum Notes* at the time, the writer of this note referred the insect to the species *Flata conspersa*, Walker, which is somewhat allied to *Phromnia marginella*, Oliv. Since then the Indian Museum has acquired undoubted specimens of the larvæ of *Phromnia marginella*, and comparison of these with the specimens from the Dooars has not disclosed any distinction of specific importance. As, therefore, both sets of specimens from tea in Northern India are likely to belong to the same species, they may conveniently be treated together under the heading of *Phromnia marginella*, for they are both undoubtedly related to this species, though the specific identity has not been made out absolutely in either case.

The most striking feature connected with the larva of *Phromnia marginella* is the dense white fluffy secretion with which the body is

covered. This gives bushes where the insect clusters a somewhat characteristic appearance which has been noticed by more than one observer.

The insect is a common one throughout Northern India. It has been reported as feeding upon *Elæodendron roxburghii* in the Central Provinces, and is likely to have several other food plants besides tea.

The figure shows the imago and half-grown larvæ, both natural size, of *Phromnia marginella;* the larva divested of its flocculent covering.

The habits of *Phromnia marginella* were carefully observed by the late Captain Thomas Hutton, who published a paper upon the subject in the Journal of the Asiatic Society of Bengal, Vol. XII, p. 898, (1843), in which he described the insect under the name of *Flata limbata.* The following summary is reproduced from *Indian Museum Notes*:—

"The insect was found by Captain Hutton on the lower slopes of the Mussoorie Hills in the North-West Provinces, the sugary secretion being only obtainable throughout the dry weather from January to June, as it gets washed away by the first heavy rain that falls upon it. According to Captain Hutton, the eggs hatch in December, and the larvæ cluster like sheep upon the food plant. They feed by sucking up the juices of the leaves, and moult several times, gradually increasing in size until the setting in of the rainy season in June, when winged imagos begin to emerge. In the imago the front wings are grass-green, with interior margins red; the posterior wings are milk-white, the body is greenish, and the abdomen is generally covered up with white flocculent matter similar to what is found upon the larvæ. The eggs are laid in considerable numbers in the bark of the twigs, a slight swelling of the wood often taking place where the eggs have been laid. The imagos move but little from the food plant and often live on until after their eggs have hatched in the cold weather. The larvæ, and to a less extent the imagos, are covered with masses of white flocculent matter, which is thought to be secreted by small glands distributed over the abdomen, and opening by minute pores in the integument. The sugary matter is said to be excreted in a liquid state by the larvæ, and drops on to the leaves, where it hardens. Little is known of the method of its origin, but it is likely to be secreted by the large gland-like organs which are situated on either side at the extremity of the abdomen in the larvæ."

APHIDÆ.

Ceylonia theæcola, Buckton (**Aphis sp.,** Green). This species was originally described from specimens forwarded to the Indian Museum by Mr. E. E. Green, who found both the winged and wingless form in large numbers on the succulent shoots of young tea plants in Ceylon. Representatives of what is undoubtedly the same species have since been sent to the Indian Museum upon two occasions from Indian tea gardens. The first to be received comprised both the winged and wingless forms, and were forwarded in March by Mr. M. K. Bamber, who has since noted that the species has been found attacking tea in most districts; the second to be received arrived from Cachar in August and comprised the wingless form only.

Ceylonia Theæcola.

The wood-cut, which is taken from Buckton's figures in *Indian Museum Notes*, shows the wingless and the winged form both enormously enlarged, also the antenna of the latter still further magnified.

The insect itself is a tiny blackish creature, the body of the winged form being only about one twenty-fifth of an inch in length.

Like other Aphidæ, *Ceylonia theæcola* feeds by sucking up the juices of the plant through its slender proboscis. Its effect on the young leaves it attacks is said to be to cause the edges to curl up and become distorted.

The life-history of the insect has not as yet been completely traced, but Mr. Green has observed that both the winged and wingless forms reproduce themselves parthenogenetically, the young settling down beside the mother and becoming full grown in about ten days after they are born. As in the case of numerous other species of Aphidæ, ants are attracted by the honey-dew secreted by the glands connected with the two large tubercles, shown in the figure of the winged form, on either side of the abdomen, and are to be found in constant attendance.

Mr. Green notes that in Ceylon the Aphid is not only liable to be devoured by the larvæ of Syrphidæ, Hemerobidæ, and Coccinellidæ, but is parasitized by a minute hymenopterous insect, the combined effect of these enemies being so considerable that it is often completely kept in check by them.

As the result of his experiments Mr. Green considers that wood ashes, powdered sulphur, and dry carbolic powder are alike useless as applications for destroying the pest. On the other hand, washes, either of dilute kerosine emulsion or of phenyle, are effective. The proportions he recommends are one part of kerosine emulsion to eighty parts of water, or one part of phenyle to two hundred and forty of water; the wash to be applied in the evening or on a cloudy day, as hot sunshine, following its application, is apt to scorch the leaves; in the case of phenyle the application of the wash to be followed the next morning by a copious drenching with ordinary water.

Coccidæ.

Chionaspis theæ, Maskell—(= *The tea bark louse,* Green). This insect was first observed in Ceylon by Green, who found that it was very generally prevalent upon tea, where it accounts for many "hide-bound" and unproductive bushes. It has since been sent to the Museum from tea both in the Kangra Valley and also in Cachar. In the Kangra Valley kerosine and soap emulsion is said to have been tried upon it with success, though the insect does not appear to have as yet caused very much damage.

The female is a little rounded flattened scale about a tenth of an inch across. It is to be found upon the branches of the older bushes, and is so much like the bark on which it rests as to be unnoticeable except on very close inspection. In its earlier stages, the male is a tiny

little white fluted scale which is often to be seen in colonies on the leaf, where it is comparatively conspicuous ; it eventually transforms into a minute creature which Green describes as bright red in colour with four prominent black eyes.

As in the case of other species of the same family, the eggs are laid beneath the female insect, which never quits the spot on which it first settles down. The larvæ are minute six-legged creatures which crawl actively about after leaving the eggs. They eventually settle down and insert a long proboscis into the tissues of the plant. Through this proboscis they gradually absorb the nutrient juices on which they feed, and in this way they weaken the plant. The female insect continues to absorb the juices of the plant throughout the whole of her existence, but the male takes no food after it becomes winged.

The figure shows a colony of male scales on a leaf natural size, also an individual scale enormously enlarged to show the characteristic ridges with which it is covered.

Male scales have been forwarded to the Museum in December from Cachar and in February from the Kangra Valley, so the winged male is likely to emerge in the early part of the year. Green has noticed that the live female scale is sometimes covered with lichens which must have taken some time to grow, so the life of the insect in this stage is likely to be prolonged. The dates of emergence, also the periods passed at different times of the year in the various stages of development, have yet to be ascertained.

In all scale insects the question of dispersion is an important one, for owing to the adult female being stationary, it is only the newly-hatched larvæ which are able to travel from bush to bush, and thus spread the evil. It is important, therefore, to ascertain at what period of the year the larvæ emerge and the extent to which they are liable to be carried by the wind.

Under ordinary circumstances insects of this kind spread slowly ; it is therefore most important to watch them carefully, for, whereas it may

be easy enough to keep them in check with kerosine emulsion or other treatment when only a few bushes are attacked, the case becomes very different when large areas have been allowed to become affected.

The hydrocyanic gas treatment, described on page 65 of this report, is especially applicable to this species.

Aspidiotus flavescens, Green—(=*A. theæ,* Maskell). This insect was originally described by Green in the pages of the *Ceylon Independent.* It has since been reported both from Assam and the Kangra Valley. According to Green's observations it attacks young plants of from one to two years' growth, and often injures them to such an extent as to make it necessary to replace them with fresh plants.

The figure, which is after Maskell, shows a piece of tea twig, natural size, covered with female scales, which are yellowish in colour and conspicuous. To the right is an enormously enlarged diagram of the newly-hatched larva to show its legs and antennæ, also the long coiled proboscis which it eventually inserts into the tissues of the plant.

The insect is likely to be very similar to the preceding in its development, but its precise life-history has yet to be traced.

Aspidiotus transparens, Green. This insect was originally discovered upon tea bushes in Ceylon by Mr. E. E. Green. A few isolated scales of what is thought to be the same species have since been found upon leaves forwarded to the Indian Museum in January 1894, from a tea garden in Jalpaiguri. Neither in Ceylon nor in India, however, has the insect yet been reported as occasioning any appreciable injury.

As seen upon the tea leaf, the scales appear as flattened semi-transparent, yellowish discs, from one to two millimetres in diameter.

The life-history of the insect has yet to be traced through the various stages of development.

Lecanium coffeæ, Nietner. This insect, which is usually accompanied by a black fungus which grows upon its secretion, was described

many years ago by Nietner as attacking coffee in Ceylon. It has since been found upon tea in Ceylon by Green, who has published an interesting account of his observations in the *Ceylon Independent*.

It has not yet been noticed upon tea in India, but has been recorded as attacking coffee in the southern portion of the Peninsula. The following account of the insect is taken from Nietner's work on the *Coffee Tree and its Enemies*.

"*Lecanium coffeæ* (Brown or scaly bug[1]). Male: Head transversely ovate-rotundate narrowed, and square in front; eyes large, black; ocelli 2, small, lateral; antennæ 9-jointed, 2nd joint smallest, 3rd longest, thence decreasing to the tip; mouth as in the male of the white bug. Thorax ample, cordiform, narrowed in front; wings 2, hyaline, 2-nerved, subcostal nerve dark pink, not folded straight down the back when at rest, but half spread out. Scutellum as in white bug. Abdomen triangular-sub-cylindrical of shrivelled appearance, with 2 lateral points, 1 central appendage, and 2 long, thin, white filaments at the extremity. The insect is still more delicate than the male Pseudococcus, of clear, light pinkish-brown colour, slightly hairy; very pretty.

"Female: Apterous, tortoise-like, yellowish, marbled with grey or light brown, sub-oval, more or less semi-globose according to age, back with one elevated longitudinal and 2 transverse costæ, uneven; split behind, at the extremity of a split bifid anal flab of brown colour; eyes marginal, black; antennæ 7-jointed, 3rd joint longest; proboscis with 1 long sucking bristle. The old individuals are light brown with a dark margin, smooth, semi-globose, fixed to the branch.

"Larvæ of female with 2 anal filaments which are lost in after-life. The larvæ and pupæ of both sexes are active, with the exception of the male pupa, which is plentiful on the underside of the leaves, where the long, narrow, oval shell under which it rests is easily discovered. This shell is transparent, and composed of 9 plates, 3 central and 3 on either side. I have occasionally found the entire underside of leaves covered with nothing but male pupæ, all dead. This species of bug affects elevated (above 3,000 feet), cold, damp, close localities, where it is found in all stages of development all the year round, the propagation being, as in the white bug, continuous. As in the latter species, the males seem to be more abundant about June and January than at any other season. The eggs, which are oval and of pinkish colour, are not actually brought forth by the female, but when they are matured the parent insect dies, the whole interior forming one mass of eggs protected by the shell.

"This kind of bug is closely allied to the lac insect (*Coccus lacca*, K.) of India.

"The brown bug is much infested by parasites, amongst which the following are the most common:—

Scutellista cyanea,
Encyrtus Nietneri,
„ *paradisicus,*
Cephaleta purpureiventris.
„ *brunneiventris.*
„ *fusciventris.*
Cirrhospilus coccivorus.
Marietta leopardina.

[1] "This insect is generally called 'black bug,' but the above is a more correct name, it being of brown colour, and only the fungus found in its company, black."

"These are all Hymenoptera of the most minute description, presenting under the microscope the most elegant forms, and for the most part the most brilliant metallic colours. The Marietta, for instance, is shotted or ocellated all over black and white, like a leopard. They can easily be obtained by putting a bugged branch, cut in convenient lengths, into a bottle, when after some time the little wasps will be found flying about inside, having made their escape from the bugs. The mother parasite lays her eggs amongst the bugs ; when hatched, the young larvæ find their way easily to the soft underside of the bugs, where they attach themselves like leeches, and, protected and fed by the body of the bug, remain until they reach the perfect state. A bug thus attacked produces of course no eggs, and, instead of the young bugs, in course of time there escape these little wasps. The shells of the old bugs are frequently found with one or two holes ; it is from these that the parasites have escaped. I have seen as many as six larvæ (belonging to different species of Hymenoptera) attached to one single bug. These larvæ can easily be seen on turning up some old bugs with the point of a penknife ; they are little white or yellowish eyeless and footless maggots, some of which can leap to a considerable distance by doubling themselves up and spasmodically extending themselves again to their full length."

THYSANOPTERA.

Thrips sp.? A representative of this group of minute insects has been recorded by Green as feeding upon the leaves of the tea plant in Ceylon, where it causes unsightly patches, especially on the backs of the leaves. As in other species of the family Thripidæ, the eggs are said to be laid on the leaf, where the larvæ and adults are also to be found. The adult may be recognised by the curious narrow hair-fringed wings which are characteristic of this family of insects. Green notices that the same species also attacks rose bushes and fuchsias in Ceylon. He found it to be subject to the attack of a minute hymenopterous parasite.

ORTHOPTERA.

Acrididæ.

Between the years 1889 and 1891 almost all the tea districts in India were visited by stray flights of the locust *Acridium peregrinum*, Oliv., from the deserts of the Punjab and Rajputana. The insect often settled in countless numbers upon the tea bushes, but seems to have disliked the flavour of the tea leaf, and to have occasioned no perceptible damage. It is unnecessary, therefore, to do more than refer to it amongst the various insects which attack the tea plant in India.

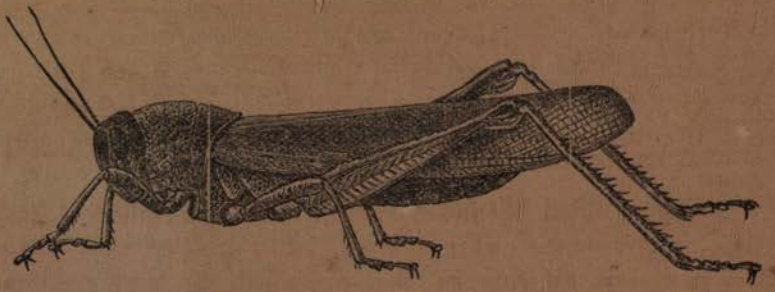
The same does not hold of other species of Acrididæ which are usually spoken of as "locusts," though they frequently differ in important points from the migratory forms.

In February 1892 injury of the kind to young tea plants was

reported from a garden in the Western Dooars. Of the insects forwarded to the agents in Calcutta, some were identical with specimens in the Museum collection determined by Dr. Henri de Saussure as his *Catantops indicus*, which is figured below natural size, while others were

a variety of the same species characterised by the absence of striped markings on the posterior femora.

Two specimens of the species *Acridium flavicorne*, Fabr., as determined in the Indian Museum collection, were afterwards forwarded as associated with the insect first reported.



A small specimen of the male of *Acridium flavicorne*, Fabr., from the Museum collection, is figured above, natural size.

In the end of February the Manager wrote that he had been to a great extent successful in destroying the insects, and that he had not heard of their appearing on any of the neighbouring gardens. The method adopted was hand-collecting by coolies, who were paid two annas per hundred insects. Up to the date of his letter the Manager estimated that he had destroyed 31,770 insects in this way, with the result that they were getting so much scarcer that, at the time he wrote, the coolies were only bringing in about 25 per cent. of the daily number they had been able to obtain when hand-collecting was first started.

Acrididæ of this kind are likely to lay their eggs in the ground. The larvæ are active grasshoppers, which differ from the adult chiefly in being smaller in size and wingless. They are active throughout their entire existence, and devour the leaves of plants in large quantities. The

individual habits of the two species referred to above have yet to be observed in India.

Gryllidæ.

Damage of sufficient extent in tea nurseries to make it occasionally worth while to keep children employed collecting the insects by hand has been noticed as caused by crickets in Assam. The only occasion on which representatives of the insect concerned have been sent to the Indian Museum was in July 1893, when some larvæ of the species *Brachytrypes achatinus*, Stoll., as determined in the Museum collection, were forwarded from Jorhat.

The figure shows the insect natural size. Like others of the same group, it transforms, when mature, into a creature very similar in appearance, but differing in the possession of large membraneous wings, which are neatly folded on the back so as not to interfere with burrowing. The eggs are likely to be laid in the ground, but this and other points in connection with its life-history have yet to be traced by actual observation.

According to information furnished from the garden in Jorhat where the specimens were procured, the insect cuts the young tea plants off level with the ground at night; in the day-time it conceals itself in a burrow from nine to eighteen inches deep which it constructs in the ground; it is specially abundant on sandy soil, and may be recognised by the shrill piping which it makes in the evening when it sits in the mouth of its burrow.

The species *Brachytrypes achatinus*, Stoll., has previously been sent to the Museum as causing serious damage to jute and rice crops in Bengal; tea is therefore likely to be only one of a number of plants on which it feeds.

Another common species of Gryllidæ also likely to attack young tea plants, though it has not actually been sent to the Indian Museum in

this connection, is *Schizodactylus monstruosus*, Drury, the adult male of which is shown below, natural size.

This species can be at once recognised by the curious structure of the tarsal joints, and also, in the adult, by its curious curled-up wings. It is known in the indigo districts as *bherwa*, and does a large amount of damage by cutting off indigo, tobacco, and other crop plants with its enormous shear-like jaws.

Termitidæ.

White ants are sometimes very plentiful in Indian tea gardens, where they occasionally do a good deal of damage, especially to young and weakly plants. The identity of the species concerned has not yet been satisfactorily ascertained, and the life-histories of the various forms have still to be traced through the different seasons of the year.

The commonest species in Lower Bengal is *Termes taprobanes*, Walker, and this is likely to be the form whose large earthen nests are often to be found amongst mature tea bushes, where, however, they seem, as a general rule, not to do very much harm. A distinct and larger species has been described by Green from Ceylon, where he observed that it was liable to attack the stems of full-grown tea bushes to the extent of completely tunnelling out the contents.

The following, which is taken from a manual of zoology prepared by the writer of this report for the Forest Department of India, gives what are said to be the general habits of Termitidæ as observed in other parts of the world. The figures are from specimens of *Termes taprobanes* in the Museum collection.

White ants live together in communities, which consist of the following four sets of individuals :—

(1) A female or queen (shown above, natural size), with enormously distended abdomen ; she is incapable of locomotion, and lays all the eggs of the community.

(2) Small ant-like neuters, which may be compared to the worker bees. They are of two kinds, *viz.*, individuals with large heads and sharp mandibles to defend the nest, and individuals with small heads to build the passages and nest, collect food, and do all the work of the community. The figure above shows the two forms of neuter, both somewhat enlarged, the natural size, in each case, indicated by a hair line.

(3) Wingless larvæ which develop into winged males and females. This form is shown below, to the left, enlarged, the natural size being indicated by a hair line.

(4) Winged males and females. The males and females fly out of the nest in clouds, generally after rain. Those of them that escape their numerous enemies are said to drop their wings and copulate. The female either finds her way back to the original nest or starts a fresh nest for herself. Her abdomen grows by distention of the membranes between the chitinous plates, until she becomes like a sausage, two or three inches long, with a minute head and thorax at one end (*vide* first figure). Queens in several stages of development may sometimes be found in a single nest. The figure above, to the right, shows a young queen shortly after dropping her wings and before the abdomen has grown very much. The figure is somewhat larger than life, the natural size being indicated by a hair line at the side. Below is a figure of one of the winged forms, natural size.

Various suggestions for dealing with white ants in tea gardens are given by Bamber in his work on the *Chemistry and Agriculture of Tea*, pages 254 and 255.

ACARINA (MITES).

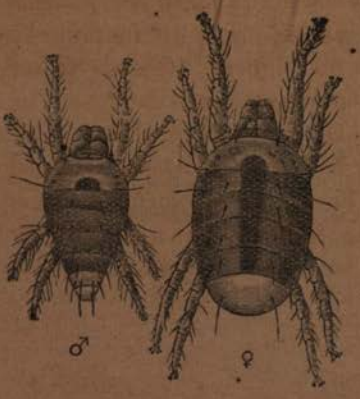
Teranychus bioculatus, W. M. (Red spider). This mite, previously known to tea planters under the name of "red spider," was described by Mr. Wood-Mason in his *Report on the Tea Mite and Tea Bug of Assam, 1884.* It has since been identified by that careful observer Mr. E. E. Green [1] as belonging to the same species as the "red spider" of the coffee tree, described many years previously by Nietner[2] under the name *Acarus coffeæ.*

Unlike both "mosquito blight" and "green fly blight," the red spider of the tea plant chiefly confines its attack to the mature leaves. It is

[1] *Insect Pests of the Tea Plant, No. 7.*
[2] *Observations on the Natural History of the Enemies of the Coffee Tree in Ceylon.*

essentially a hot-weather pest, and almost completely disappears when the rains break, though colonies are subsequently to be found upon sheltered bushes.

In Ceylon, where red spider also attacks tea, Mr. E. E. Green has noticed that the tomato plant is likewise liable to suffer. The figures,



which are after Wood-Mason, show the male and female mite both enormously enlarged, The male is considerably smaller than the female, the latter being described as about one twenty-fifth of an inch in length.

The following is taken from Wood-Mason's report :—

"The mite lives in societies on the upper surface of the full-grown leaves, beneath an exceedingly delicate web, which it spins for itself as a shelter. This web, ordinarily invisible to the naked eye, is often rendered visible by the deposition upon it of dew in minute globules, which give to the leaves, when bathed in the morning sun, an indescribably splendid appearance of being sprinkled over with minute diamonds. I believe that this web serves chiefly as a protection to the tiny arachnids from dew and light showers, for heavy rain, especially if long-continued, breaks up the sheltering webs, and thus leads to the disappearance, if not to the destruction, of the pest.

"The mites lay their eggs in hollows, close to the ribs of the leaves usually. The eggs are oblate spheroids, flatter at one pole, by which they are firmly and broadly attached to the leaves, than at the other, at which their transparent shell is suddenly drawn out into a long and tapering and slightly curled glossy process. They are red, like the mite itself, and at the close of segmentation present at their surface a beautiful reticulated pattern, due to the presence of a concentrated and dark-coloured layer of protoplasm around the nucleii of all the cells of the blastoderm. The young arachnids leave the egg as six-footed larvæ, which do not attach themselves as parasites to the bodies of insects and spiders, as do their distant relations the Trombidiidæ, nor undergo any of those strange changes which many other mites pass through in the course of their development, but attain to the adult condition by a simple change of skin that usually, though not perhaps invariably, is made on the same leaf as that on which they emerged as larvæ from the egg. The shells of the hatched eggs remain glued to the leaf for some time as microscopically small objects resembling porcelain saucers.

"Preparatory to the final moult the mites draw all their legs in under them, become perfectly motionless, and appear to change from red to white; but no change of colour actually occurs, the appearance of whiteness which the thin and colourless old skin presents being due to the access of air to the interval between it and the new.

"The male differs from the female not only in size but also remarkably in the form of the body. The former sex is the smaller, and in the shape of the body resembles a plover's egg, being broadly rounded at the anterior end and pointed posteriorly, while the latter resembles an egg which is similar and semi-circular in outline and nearly equal at both ends.

"The males are most solacious little creatures, and the very remarkable mode in which they couple with the female has frequently been witnessed by me under the microscope. After a brief courtship, which consists in actively and excitedly careering round and round the female for a few seconds, in caressing her with his sensitive feet, and in exciting her by repeated thrusts from his needle-shaped and protrusible mandibles, the male embraces the female by placing his two front pairs of legs upon the upper surface of the end of her body, then suddenly dives downwards and forwards beneath her body, retaining firm hold of her by means of the claws and suckers with which his legs are furnished, and finally extends and recurves the end of his soft and flexible body until his genital aperture, which is placed on the ventral surface just in front of the terminal anus, is opposite to that of the female, which occupies a similar position.

"The mite injures the tea plant by repeatedly puncturing the leaves and pumping out the liquid contents of the epidermis (? and parenchyma) through the punctures by the aid of the pharyngeal pump with which it, like all other arachnids, is provided. A freshly-punctured leaf exhibits a regular and pretty pattern of irregular star-shaped patches of light green worked upon a dark ground. The pale spots are caused by the mites, and in the centre of nearly every one of them two most minute punctures can only with difficulty be made out, even by the aid of a microscope. In order that the manner in which the punctures are made may be understood, it will be necessary briefly to describe the mouth-parts of the animal. These consist of (1) a conical rostrum or beak, the sides of which are embraced and partly formed by (2) a pair of short, stout and jointed palpi or feelers which end in a pair of pincers, and answer to the great claw-bearing feelers of the scorpion and to the first maxillæ of an insect; and of (3) a pair of jaws or mandibles, which do not enter into the composition of the beak above, and in front of which they lie, but between which and them, on the contrary, there exists a wide interval. The rostrum is not serrated on the edges so as to resemble that of an ordinary tick, as it is in the European *T. telarius*, but on each side of the minute slit-like opening which constitutes the mouth, and is placed at its lower extremity, it bears two minute curved and probably movable spines. At the ends of the short fixed arms the pincers of the feelers open the ducts of the glands, which furnish the viscid secretion wherewith the animals spin their protective webs. The mandibles or jaws are a pair of long and delicate needle-shaped rods, which ordinarily lie retracted out of sight into their sheaths ready to be shot out with lightning rapidity. It is a remarkable fact that the sheaths, which appear to be none other than the basal joints of the mandibles, retain their primitive embryonic distinctness throughout life, and do not coalesce in adult life so as to form a single common sheath, as they are said to do in *T. telarius*. It is more probable that the leaves are punctured by these mandibular needles, and that the two little movable spines placed at the sides of the rostrum serve only to keep the sucker-shaped elevation around the mouth

closely applied to the wounded spots in order that the buccal pump may act as effectually as possible, than that the latter perform the double duty of lancets and retentive hooks.

"The Tea-Mite is an excessively minute animal, the female measuring only about one twenty-fifth of an inch, or about one millimetre, in length between the extremities of the outstretched anterior and posterior group of legs, and the male being about one-sixth smaller. The egg-shaped body is divided, except when inflated to its fullest extent by imbibed tea juices, by distinct grooves into six divisions in the female and into seven in the male; and each of these divisions, as to which it is exceedingly doubtful whether they represent true segments, bears two pairs of long and stiff and backwardly directed white hairs, forming four longitudinal series placed two on each outer third of the upper surface; the first segment, which has only one pair of hairs, and is moreover longer in the male than in the female, carries, in both sexes, two groups of two unequal eyes, forming two pairs, one of which, the anterior, is smaller than the other.

"To the naked eye the Tea-Mite appears as a dull blood-red speck, but under the microscope presents itself as a much brighter and more variously coloured object, its legs being of a pale flesh-colour adorned with a light crimson stripe, the front segment of the body bright crimson with a semi-circular mark in the middle of its hinder margin, concolorous and in contact with the deep blood-red of all the remaining segments in the female, which is dark blood-red from the front end of the second segment to the extremity of the body, but of the four following segments only in the male, which has the two terminal segments bright crimson, like the front of the body. The legs are sparingly clothed with long and colourless hairs, and they are all terminated on each side by one or two curved bristles and in the middle by a single hooked claw, on either side of which there spring from the apex of the terminal joint of every limb two delicate glassy threads with enlarged tips, forming long and thin-stalked suckers, by the aid of which the mites are enabled to retain their footing and to walk securely over the leaves, and the males to clasp the females firmly by the back during copulation. In crushed specimens which had been rendered transparent by reagents, a pair of highly refractive and spheroidal solid bodies having a faint concentric structure was always to be made out beneath the skin in front of and internal to the eyes, in a position, therefore, corresponding as closely as possible with that in which Claparède never failed to find in embryos, but only in embryos, of *T. telarius*, a pair of sacs each containing a pear-shaped solid body.

"I propose for the Tea-Mite, which would appear to be unknown to science, the name of *Tetranychus bioculatus* in allusion to its double (really two pairs of) eyes.

"The Tea-Mite, so far as I have been able to make out, usually first affects small patches consisting of a few bushes, whence it rapidly extends over the whole or a large part of a garden. It always seemed to me to consist of numerically larger and more active societies on the bushes of very old gardens, from which it never appeared to be entirely absent, as vigorous societies were to be obtained therefrom as often as I wanted fresh material for my observations.

"The view entertained by many planters that this pest is carried to gardens and distributed over them by insect agency does not receive the least support from my observations. Moreover, the analogy of the closely-allied European species, *T. telarius*, is wholly opposed to such a notion, which doubtless owes its origin to the Tea-Mite having been mistaken for some one of the numerous red or reddish-yellow Mites belonging to totally different groups, which do commonly occur parasitically on the outside of the bodies of the most diverse groups of insects—a kind of parasitism which is of such common occurrence that I have rarely if ever sorted the contents of a

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bottle containing a mixed collection of terrestrial arthropods preserved in spirits without finding one or more individuals, or even species, of these parasitic arachnids, and the least observant amongst us must have repeatedly met with instances of it.

"When first attacked by the mite the leaves have the appearance described above; but as the punctures increase in number they gradually assume a dull, dirty coppery-reddish tinge, become dry and bent and cockled, and finally fall to the ground, leaving, in extreme cases, the stems and branches of the bushes bare. A badly-smitten garden may be recognised from a distance by its red colour."

The principal points in connection with the life-history of the mite which remain to be ascertained are the number of generations in the year and the length of time spent in its various stages of development.

The mite is only capable of slow locomotion, and therefore spreads in the first instance very gradually. From Green's observation of its presence upon sheltered bushes in the rainy season, it may be expected to be found to lie up in this manner until the time comes round for it to recommence operations upon the bushes generally.

In consequence of its frequent localisation in certain areas, red spider lends itself specially to destruction by artificial means and numerous experiments have been made to this end.[1]

Sulphur *versus* red spider.

The most promising agent for use against red spider appears to be sulphur in one form or another. The only method of applying it which seems as yet to have been adopted in Indian tea gardens upon any considerable scale is that of dusting flour of sulphur over the affected bushes. This is said to have been first tried in the Darjiling district, and has since been taken up elsewhere.

The following series of reports by Mr. G. F. Playfair, furnished through the courtesy of Messrs. Barry & Co., give a full and excellent account of the experience of a Cachar tea planter in the matter.[2]

14th March 1893.—"I am taking advantage of the present hot weather to apply the sulphur as advised by Mr. Christison, who makes a point of putting it on during times of bright sunshine. I find the quantity used is exactly one hundredweight to the acre, and cost of application Rl-6. Up to date I have sulphured 60 acres, and will keep on as long as the sulphur lasts or the drought continues. I have given up my original intention of applying half now and the balance when red spider becomes active, as I find in places a good deal of blight is already visible, and I am hopeful that the sulphur will stamp it out before the insect has time to propagate. Some experiments with the mosquito itself tend to show that it dies if lightly dusted with the sulphur."

25th March 1893.—"Red spider began to show itself all over the early pruned sections, but I applied the sulphur as fast as I could, and wherever the application

[1] Amongst other preparations, decoctions of tomato leaves in water have been strongly recommended for spraying over affected bushes. The number of applications required, however, to rid a single bush in this way of the pest is so great as to render the treatment inapplicable for large areas. In view of what is known of the habits of the pest, it has been suggested as probable that spraying the same number of times with water alone would be almost equally effective.

[2] Most of these reports have appeared in *Indian Museum Notes*.

was made not a trace of spider remains. Altogether 138 acres have been sulphured with the five tons sent up. The sulphuring has been most carefully done, either a Babu or Mr. Burns being in constant attendance, and, as far as can be judged at this early stage, the experiment is likely to be a very remunerative one. Whether or not the spider will come back remains to be seen, but at the present moment I can guarantee there is not a single affected bush over the whole 138 acres."

13th April 1892.—"The drought still continues, only ·86 inch of rain having fallen in April, the total to date since the 1st January being 4·05 inches. Notwithstanding, Bundookmara is looking very well and would flush at one with rain. The great heat and dryness of the soil have brought on some red spider, but not much, as the early pruned sections were all sulphured, and the later pruned have not yet sufficient foliage to make red spider harmful. It is gratifying to observe that not a single plant over the sulphured area shows the slightest sign of red spider, and blight, which had appeared with the first growth, has also entirely disappeared. I believe that in dealing with the one disease we have also dealt with the other, and that the early part of the season will be free from blight."

18th April 1892.—"There have been no charges in connection with the sulphur—it having been brought up to the garden by my own boats. From the invoice and estimating for freight, I make out the five tons have cost approximately R900 and applied to the bushes about R8-4 per acre. A very small increase in yield will cover the expense, and I am hopeful, from the look of the sulphured sections, of proving to you that the money has been well spent. You must not expect to see any very startling increase in outturn in consequence of the sulphuring, as I have naturally treated those flats which are the poorest and most in want of encouragement; but if by doing away with spider, and possibly blight, I can in time bring these flats from poor to good, the gain will be great indeed. At the present moment I believe that the application of sulphur will result in an increase of a maund of tea per acre; it certainly will be so if blight is mitigated as well.

"I have written out extracts from my diary, giving you full particulars respecting the way the sulphur was applied, the state of the bushes before, and the immediate result after application. It will be interesting to compare this report with subsequent ones which I will send from time to time in the same form."

Abstract of diary.—"The treatment was begun on 7th March 1892 and completed on 21st of the same month. Sixty acres were treated at the rate of one hundredweight to the acre, which gave a very sufficient sprinkling, sixty-seven acres at the rate of two hundredweight to three acres, while eleven acres were treated with a mixture of one part of sulphur to two parts of sifted lime. The tea that was treated was of the 'China' variety. The bushes were rather below than above the medium size. They had not put out much growth owing to the drought. Red spider had appeared, and careful examination showed that it was present in many places. The application of the sulphur was made through *markin* cloth by simply shaking the bag over the bush. Where water was available the bushes were first splashed with water, but over a considerable area the application was made without previous watering. The sulphur adhered fairly well even on dry bushes, in spite of the high wind which blew both at the time that the treatment was going on and afterwards. The average cost of applying the sulphur was about R1-4-9 per acre, including the purchase both of the cloth and also of the *kulcies* for watering. As far as could be made out, *provided the sun was strong*, bushes powdered in the morning had all the red spider killed by evening. After sulphuring the bushes were examined daily, but the only bushes on which red spider could be found were one or two which had been treated with the mixture of lime and sulphur; even here, however, very careful search was required to

find live insects. On 16th April it was noted that red spider was to be seen in all parts of the garden except the sulphured area, while neighbouring gardens were very much affected by it. The sulphured area was the first pruned and should, under ordinary circumstances, have been the most affected. With regard to the effect of the sulphur treatment on mosquito blight, some mosquito blight insects were caught and experimented with on 23rd March. When sulphur was powdered on to them it adhered to the hairy parts of the body and legs to a considerable extent, but the insects did not die at once, though putting them in this state under a glass in the sun was fatal to them. After applying the sulphur all signs of blight disappeared, careful search not revealing a single punctured shoot. It must be added that little blight could be found on other parts of the garden, but the flats which had been treated with sulphur were always the ones to be first attacked.[1]

6th May 1892.—"I have no objection whatever to Mr. Cotes making use of any information he may have derived from my writings, and will be glad to supply him with further notes from time to time. I strongly object, however, to trying Mr. Cotes' suggestion about sulphur soap instead of the pure sulphur (except as a supplementary experiment) for this reason.[2]

"The action of sulphur against red spider is now proved beyond doubt, and requires no comment. It also seems to have killed off the blight insect; and if this is a fact it would be a vast pity to operate against the one disease without the other in future, for the sulphur soap wash, however efficacious against spider, could not be expected to do much harm to a winged insect like blight. Moreover, the wash requires special apparatus for application, and the purchase of such insufficient quantity to go over hundreds of acres quickly would be prohibitive. That blight has actually been killed out over the sulphured area seems to me a certainty. On the 14th March I wrote to you saying that my original plan of distributing the sulphur had been changed owing to a considerable amount of blight being noticeable. This is proof that blight *was* there; it is equally certain there is none *now*, and the accompanying extract from my diary will prove that during the past ten years I have invariably reported blight not later than the week ending the 23rd April, and almost always in the same spot, which this year is free. I am not yet in a position to ask you for a further and larger supply of sulphur for next year, but trust to be able to do so when I can lay the result of the pluckings of the sulphured and non-sulphured areas before you."

23rd June 1892.—"Since the 1st June, I have been keeping a record of the pluckings of sulphured and non-sulphured areas, and on a separate sheet I give you the results. You will observe that over three weeks' plucking, the average per acre is 11lb of leaf in favour of the sulphur for every time the acre was plucked, or, say, 33lb in all. At first sight this does not appear a very large increase, but you must remember that only the worst places were sulphured, and now it is evident these sections are doing rather better than the rest. Also I have refrained from comparing pluckings till red spider was fairly on the mend; had I done so from the beginning of May the difference would have been too marked and misleading.

"Leaving out of consideration all differences between sulphured and non-sulphured areas, and taking them as of the same value, the difference in favour of the sulphured would be 44lb leaf or 11lb tea per acre for the whole month. The cost of treatment

[1] Very careful experiment will be necessary before concluding that sulphur is actually effective against mosquito blight, for the experience of entomologists in other parts of the world seems to be that while sulphur is exceedingly active against all kinds of mites (of which red spider is one), it has little effect on insects.—E. C.

[2] "It may be noticed that washes made of soap and sulphur combined have been recommended both in the United States and in England for use against mites like the *red spider*. The wash is sprayed on to the plants by means of a force pump fitted with a nozzle to give a very finely divided spray. This method of applying the sulphur may possibly prove cheaper and more effectual than dusting it on to the leaves, though Mr. Playfair's experiments with sulphur in powder seem so successful as to leave little to be desired. Compounds of soft soap and sulphur can now be purchased in England ready made, so as only to require the addition of water. In her fifteenth annual report on Injurious Insects, Miss Ormerod mentions the Chiswick Soap Co., of Chiswick, England, as a firm from which the mixture can be procured."—(*Extract from "Indian Museum Notes."*)

amounted to R8-4 annas per acre, so that with tea at 6 annas per pound all expenses would be recovered in two months.

"I am quite convinced, however, that the sulphur will give me quite one maund of tea per acre by the end of the year."

23rd June 1892.—

Date.	Sulphured.		Non-sulphured.		Remarks.
	Acres.	Outturn. Mds. lb	Acres.	Outturn. Mds. lb.	
June 1	77·25	43 43			Indigenous omitted from both. Thirty acres of non-sulphured manured with oil-cake, against no manuring on sulphured area.
2	31	19 47			
3			60·25	55 65	
4			36	44 14	
6	38	46 45			
7	19·25	19 10	13·25	15 5	
8	64·50	39 48			
9	6	8 46	25	20 38	
10			62	52 50	
11			8·50	10 4	
13	44·25	32 59			
14	34	27 45	3	2 40	
15	19·25	18 55	21·50	15 59	
16	22·50	27 39	50·75	23 25	
17			30	16 20	
18			7	4 18	
20	41·25	29 55			
21					
Total	322·25	310 12	317·25	259 76	
		77		66	Average per acre each plucking.

14th May 1893.—"I had bad luck as regards weather, March being a wet month this year. Reserving 2 cwt. for experimental purposes, the balance of 5 tons of flour of sulphur was applied to 135 acres, of which 85 acres had good sunshine for between ten and fourteen days before being washed by rain; 28 acres for two days; and 22 acres were powdered in the morning and washed in the evening. Still the effect seems to be much the same over the whole area which is *practically* free of spider. I qualify the latter statement, as a bush every here and there does show up red this year, which was not the case in 1892. The number is altogether insignificant, being under 1 per cent., but I mention the fact as being curious and unlike the past season's experience.

"The only point worth noting this year is, that a single day's good hot sunshine appears sufficient for the sulphur to do its work.

"The 138 acres treated in 1892 have for the most part very little spider. Some of the worst sections, especially those subject to flooding, show up a little red, but not one quarter as bad as in former years; on the other hand, there are large stretches with no spider at all.

"On the first signs I went over 72 acres with the one cask of 2 cwt. reserved for the purpose, sprinkling every bush that gave the slightest show. From the ground gone over

and quantity of sulphur used, I calculate the affected bushes amounted to just 3 per cent. With a little more sulphur I could have checked the disease over the remainder of the 138 acres, for I am glad to say the 72 acres are now quite free, whereas the rest have perhaps 10 per cent. of the bushes red. The 11 acres treated with sulphur and lime which I reported as unsuccessful last year have at least 50 per cent. attacked.

"Now that I know more about sulphur and its effects, I am convinced I made a great mistake in not applying it immediately after pruning. I have several reasons for saying so, amongst which are—(1) Red spider must hybernate somewhere in the bush; it cannot come spontaneously. One invariably sees it start on the old leaves, and work gradually up to the new growth which is always the last attacked, and I should not be surprised to learn that it remained through the cold weather in the *bark*. Therefore an application of sulphur in January ought to be as successful as in March. (2) The sulphur would go very much further on newly-pruned bushes, and would also *search out the bark*, which it cannot do after the leaves form a covering. Moreover, there would be no fear of heavy rain for at least two months, nor would there be the high winds of February and March which waste a good deal of sulphur. (3) Although Mr. Cotes is not convinced on the subject, I still hold to my opinion that sulphur has an influence on blight. My experience of this year is exactly that of last,—*viz.*, that on the sulphured area there is still no blight, but a good deal on other places; in fact it is unusually bad for the early season of year."

Late pruning *versus* red spider.

The following is an extract from an interesting report by Mr. A. H. Green upon the subject of late pruning as a check on red spider in Assam. It has been furnished through the kindness of Messrs. Barry & Co.[1]

8th May 1893.—"The weather has been unusually cold for time of year. Red spider has also been showing on parts of gardens, but is getting less. The gardens promise well, and with suitable weather should soon make up and pass last year.

"In connection with red spider, it may be of interest to you to note that this blight rarely, if ever, attacks bushes pruned after the last week in March. For three years I have kept small plots of bushes unpruned till last week of March, and this year I kept some 30 acres unpruned till after third week of March, the difference of the plots so treated being now very marked; that portion of same plot early pruned being more or less covered with blight, and the later pruned throwing out shoots without a sign of blight.

"My neighbour at Coolie Kusie has tried the same experiment with so far like result, I am of opinion that late pruning—not before first week in April preferably—will be found the best remedy or rather preventative for this blight; the bushes liable to it will probably get the blight on them before they are pruned, but the pruning will remove a good deal, and the bush will throw out shoots straight away without a check.

"Blighted bushes give little or no leaf for several weeks, and the little leaf given before they become attacked by the blight, would probably be more than made up by the unpruned bush up to beginning of April.

"I am referring to ordinary or light-pruned tea; heavy pruning is probably best done early, and, further, red spider does not attack heavy-pruned tea as a rule."

Mites other than Red Spider.—In India red spider (*Tetranychus bioculatus*, W. M.) is the only mite which has hitherto been recorded as attacking the tea plant, but in Ceylon the two totally distinct species *Typhlodromus carinatus* and *Acarus translucens* have been discovered by

[1] It should be observed that in Ceylon a bad attack of red spider is said to be very liable to follow a few months after heavy pruning (*vide* Green, *Insect Pests*, No. 7).—E. C. C.

Green, who found that they were responsible for much of the damage commonly attributed to red spider, from which, however, they should be carefully distinguished. The following is a summary of Green's observations as published in the *Ceylon Independent.*

Typhlodromus carinatus, Green. This is a minute dull-coloured mite characterised when full grown by a series of fine white longitudinal ridges of waxy secretion down the back. It feeds both on the upper and under surfaces of the leaves, especially along the margins. When attacked the leaves become dry and bronzed, but they do not curl up as when affected by red spider. The life-history of the species would seem to be very similar to that of red spider, but has not yet been completely traced.

Green recommends treating nurseries affected with this mite with washes of one part of kerosine emulsion to eighty parts of water, or one part of phenyle to two hundred and forty parts of water. The application to be made in the evening and followed the next morning with a washing of pure water, unless rain has fallen in the meantime.

Acarus translucens, Green.[1] This is a minute amber-coloured mite with a clouded stripe down the middle of the back. It confines its attack to the flush where it is to be found on the buds and young leaves. It seems to be unaffected by rain and continues its ravages all the year round, with the result that it occasions a large amount of damage on many estates in Ceylon. Green found the mite in all stages of development, including eggs, larvæ, and adult males and females, on the young leaves. He recommends the persistent plucking of every shoot on affected bushes.

For further particulars about these two species reference should be made to Green's work.

INSECTICIDE APPARATUS LIKELY TO BE USEFUL UPON INDIAN TEA GARDENS.

Artificial means of destroying insects are now widely employed both in the United States and in Europe, and no reason is apparent why they should not be adopted for use in India. This is especially the case where such valuable crops as tea and coffee are concerned, which are likely to repay the cost many times over in increased productiveness.

The first point to notice is the fact that the best time to employ insecticides is as soon as ever the blight appears, and without waiting

[1] In Nietner's *Enemies of the Coffee Tree*, second edition, Colombo, 1880, the name *Acarus translucens* is given to a mite found associated with the scale insect *Lecanium coffeæ*, Nietner, on coffee bushes in Ceylon. It does not appear whether the two forms are identical.

until appreciable injury has been done; for preparations which might profitably be employed to kill off the pest on the few bushes where it first appears, and thus prevent its spreading wholesale throughout the garden, are liable to prove too troublesome and expensive for application at a later date when large areas have become affected.

Methods capable of more or less completely destroying almost every form of insect blight have now been invented in America and Europe. The relative merits also of almost every substance which possesses insecticide properties have been so fully thrashed out by the United States entomologists, that little is likely to be gained by attempts to invent new insecticides in India. What is rather required is to adapt already existing systems to the special requirements of the tea industry and to ascertain by experiment how to attain the most satisfactory results with the least possible expenditure.

The period immediately after pruning, when the bushes are small and thin, is no doubt a favourable one, under certain circumstances, for treating large areas for the destruction of such pests as red spider and scale insects which remain all the year round upon the plants; but the shock likely to be caused to the bush by the application of poisonous substances must also be taken into consideration, and the object should be to select a moment for operation when the insect is most open to attack and the plant least liable to be affected.

With a few unimportant exceptions, the species which attack the tea plant in India are confined to Southern Asia; they are sufficiently closely related, however, to corresponding American and European forms to be likely to be to a very large extent amenable to the same insecticides. For this branch of the subject, therefore, the masterly publications of the United States Entomological Department are of the greatest use, though great care must be taken only to institute comparisons between species which have essential features in common.

The sulphur treatment for red spider, which has been fully described on pages 52 to 56 of this report, may be said to have already passed into the stage of practical utility in India. Sulphur has long been employed both in Europe and in America for the destruction of mites of all kinds, of which the red spider of the tea plant is one. Sulphur is therefore likely to be useful in India, not only against red spider but also against such species as *Typhlodromus carinatus* and *Acarus translucens* referred to on page 57 of this report. Whether, however, the system, hitherto adopted in Indian tea gardens, of sprinkling the sulphur in a dry powder over the bushes, will eventually prove to be the cheapest and most effectual method of application, is open to considerable doubt. Both in England and in America this system seems to have been generally abandoned in favour of mixing the sulphur with soap which is then

dissolved in water and sprayed in this form over the affected plants. Cakes of soap and sulphur mixed ready to be dissolved in water are said to be already an article of manufacture in England (see foot-note to page 54). This substance can therefore be easily procured and would seem to be well worth trying upon an extensive scale, before concluding definitely that the system at present adopted is incapable of further improvement.

Sulphur is one form or another at present to be the most promising agent for use against mites generally. From the experiments, however, which have been made elsewhere, it is almost certain to have little effect on pests which belong to the zoological group Insecta. In other words, while mites are exceedingly susceptible to sulphur, insects (properly so called) are but little affected by it.

It must be borne in mind that in order to give satisfactory results, not only must an insecticide be carefully prepared and applied in the right proportions and in the proper manner, but it is necessary to ascertain that the nature of the insect, which it is required to destroy, is such as to render it amenable to the particular form of insect poison employed. The necessary caution also must be exercised in cases where the application is hurtful to the higher animals and man.

From the contradictory statements which have been made by those who have experimented in India with identical insecticides, it appears that a good deal of misunderstanding exists with regard to the nature of these substances. In particular the fact seems to be often overlooked that because an insecticide is either effective or the reverse when applied in a particular manner against one insect, it by no means necessarily follows that it will have the same effect when used, either in the same or in some other manner, against a different species.

With this preface we may proceed to consider a few of the more important insecticides and mechanical appliances invented in America for the destruction of insects. It will be unnecessary to repeat what has already been said either about the sulphur treatment which has been fully dealt with above, or concerning such methods as that of applying bisulphide of carbon to root-feeding forms which has been sufficiently described on page 6 under the heading Melolonthini.

The subject may most conveniently be considered under the following five headings :—

(1) Kerosine Emulsion.
(2) Pyrethrum.
(3) Arsenical Washes.
(4) Hydrocyanic Gas.
(5) Hopperdozers.

Kerosine Emulsion.

This insecticide is said to be very widely used in the United States against Aphidæ, scale insects and other soft-bodied insects, which feed by sucking up the juices of plants by means of a proboscis inserted in the tissues of the plant, and which are hence little affected by non-volatile poisons distributed on the surface of the leaves. In particular it is said to have proved very valuable in Florida for ridding orange trees of scale insects.

In India it has been favourably reported upon for destroying the green scale bug, which is one of the most inveterate blights of the coffee tree, also for dislodging white ants. It is further said to have been successfully used in the Kangra Valley for destroying scale insects on tea, and has been recommended by Mr. Green to the attention of Ceylon tea planters for dealing with the five-ribbed tea mite (*Typhlodromus carinatus*, Green), the tea Aphid (*Ceylonia theæcoala*, Buckton), and such scale insects as *Chionaspis theæ*, Maskell. It is further worthy of very much more careful trial than has yet been accorded it against such insects as mosquito blight and green fly blight. For although it may be impossible, without seriously injuring the foliage, to make it sufficiently strong to destroy the winged adult forms of these species, which fly off as soon as spraying commences, it by no means follows that it will be ineffectual against the wingless larvæ which also subsist upon the tea bush, where they not only do a considerable amount of injury themselves, but also eventually develop into the winged form. No doubt the best thing would be an insecticide capable of destroying, on the first application, alike the eggs, the larvæ and the adult insects, without injury to the tea bush, but failing this it is quite possible that useful results may accrue by the persistent use of less powerful agents, provided they are really effectual against any one of the forms through which each individual insect passes the course of its existence. For, to take a single instance, it is obvious that there can be no winged mosquito blight to lay eggs, if all the wingless larvæ have been destroyed as fast as they appeared.

Kerosine emulsion is made by violently churning two parts of kerosine oil, the purer the better, with one part either of milk or, better, of soap solution; the soap solution to be made by boiling from a quarter of a pound to a pound avoirdupois of common yellow soap or whale oil soap with a gallon of water. The resulting emulsion is then mixed with from nine to fifty parts of water. The churning is best done when the mixture is warm and should be continued until a thick cream like emulsion is produced, almost like butter in consistency. In the

case of soap solution the necessary temperature may conveniently be obtained by adding it hot off the fire to cold kerosine oil.

The writer of this report has succeeded in making an excellent emulsion on a small scale by the simple process of half filling a beer bottle with a mixture of kerosine oil and milk and then setting a cooly to beat it on a pad of cloth. This process, however, is far more laborious than that recommended in the United States, where the regular plan is said to be to drive the mixture backwards and forwards for five or ten minutes through the force pump used for spraying the plants. All that is necessary in this case is to insert both the feed-pipe and the nozzle of the force pump into the mixture and then to work the pump until the thickening of the fluid shows that the union of the two liquids has been effected.

The object of emulsion is to enable the kerosine oil, which is the active insecticide agent, to mix with the water required to dilute it so as to prevent injury to the foliage, The amount of water that should be added varies according to the nature of the plant and that of the insect which it is required to destroy.

When used carelessly kerosine emulsion is certain to burn the leaves to a more or less serious extent. This is especially the case when hot sunshine follows the application, but can easily be avoided by using the wash in a sufficiently diluted state. Much also depends upon the manner in which the application is made, for to obtain the best results it appears to be essential that the spraying should be done with a force pump fitted with one of the modern "cyclone" nozzles originally invented in the United States Entomological Department. These cyclone nozzles are so arranged that the liquid issues in the form of a fine mist-like spray which envelopes the whole plant and covers every portion of it with the tiniest drops imaginable. This method of application not only makes the same amount of wash go very much further than would otherwise be the case, but the mist-like spray, penetrating as it does in all directions, is infinitely more effective, so far as killing insects is concerned, than large drops which are almost certain to leave portions of the bush untouched, besides running off on to the ground instead of adhering to the leaves.

So-called "knapsack force pumps" are now made with a reservoir which can be strapped on to the back of the operator, who thus conveniently carries a considerable supply of the wash along with him while he sprays the plants by means of an aquapult force pump fitted with a cyclone nozzle. Further improvements will no doubt suggest themselves in the form of the apparatus when it comes into general use upon tea gardens in India. It is important, however, to notice that very satisfactory force pumps are already manufactured both in Europe and in America, where they are used for various purposes.

With regard to the amount of dilution required, a mixture of twelve parts of water to one of emulsion has been recommended in America as a safe wash for ordinary purposes. In Ceylon[1] Mr. Green has found so weak a wash as one part of kerosine emulsion to eighty parts of water sufficient when applied in the evening to kill aphids and mites upon the tender shoots of tea plants in nurseries. He recommends that even this should be followed with a washing of water the next morning if no rain intervenes in the night. It will probably prove, however, that very much stronger applications can be used with safety, without subsequent washing, especially upon the older bushes, when the necessary precautions are taken to apply in a very fine spray when the sun is off the plants.

Arsenical Insecticides.

The best known of these useful insecticides are *Paris green* and *London purple* respectively. Without going into the question of their chemical structure, it is sufficient to say that they are brightly coloured substances which are exceedingly poisonous, not only to insects but also to all forms of animal life. On this account they were for a long time looked upon with very considerable distrust. Of late years, however, it has been shown that when properly used the amount of poison which it is necessary to distribute is so small that with ordinary care they can be used with entire safety. As the result they are now employed upon a very considerable scale, especially by fruit-growers in the United States.

Like kerosine emulsion they require to be diluted to an enormous extent with water and applied to the foliage in the form of an exceedingly fine mist-like spray. The poison is thus distributed over the leaves and acts, not like kerosine emulsion by actual contact with the insects, but by poisoning the leaves upon which they feed. Paris green and London purple are thus principally effective against such caterpillars, grasshoppers, and beetles as actually eat the substance of the leaves, and are less useful against species which feed by sucking up the juices of the plant by means of a proboscis. It may be noticed, however, that satisfactory results have been obtained with London purple[2] in the Saharunpore Botanical Gardens, North-West Provinces, not only against caterpillars but also against a Jassid which attacks the flower of the mango tree, and which is closely related to the green fly blight of tea. In this case the precise action of the wash is somewhat difficult to explain.

[1] *Vide* his papers in the *Ceylon Independent.*

[2] The London purple experimented with in this case had been furnished to the India Museum by Messrs. Hemingway & Co., of 60, Mark Lane, London, E. C.

On account of their poisonous nature neither *Paris green* nor *London purple* should be used under any circumstance whatever upon tea bushes where plucking is going on. And no leaves or buds, which were in existence at the time that the spraying was done, should on any account be made into tea. Provided, however, that the bushes are well washed by rain subsequent to the application, and that sufficient time is allowed to elapse before plucking for an entirely new flush to appear, it would seem to be impossible for the tea to be affected in any way. As an additional precaution, however, it might be as well in the first instance to have the leaf tested chemically for the poison, though the fact that the closest investigation in the United States has failed to detect its presence in fruit picked from trees the foliage of which, only a few months previously, has been liberally treated with the wash, would seem to be sufficient indication that there is no possibility of danger upon this score.

The usual system for applying both *Paris green* and *London purple* is to simply mix the powder[1] with water and to spray the mixture, which is purely a mechanical one, over the plants. The powder, however, has a great tendency to settle to the bottom of the receptacle, and thus render the top too weak and the bottom too strong. To obviate this difficulty the mixture should be constantly stirred, and when empty the receptacle should invariably be rinsed out with water as a preliminary to refilling, for this prevents the accumulation of the poison at the bottom. A little flour is sometimes added to the mixture both to render it more stable, and also to help it to adhere to the leaves; this, however, is by no means essential, provided the other precautions are taken.

The precise amount of poison to be mixed with the water varies according to the nature of the insect and the resisting power of the foliage. When too strong the leaves are burnt, and when too weak the insect survives. Between these two extremes, however, there is usually plenty of room for the production of a satisfactory mixture.

For use against the web worm in the United States the following proportions have been recommended: Forty gallons of water, one quarter to three quarters of a pound of London purple and three quarts of flour, the solid ingredients to be mixed with the water by washing them through a strainer.

One pound of *Paris green* similarly mixed with from forty to one hundred gallons of water has been recommended for general use in America. In England for use upon young foliage, the proportions recommended have been one ounce of *Paris green* to ten gallons of water in

[1] *Paris green* is also manufactured in the form of paste to be similarly used. The paste has the great recommendation of not being liable to get blown about by the wind in mixing.

the case of plum trees, and one ounce to twenty gallons of water in the case of apple trees.

The precise strength, which it is desirable to adopt in each case, can only be ascertained by experiment. It should be remembered, however, that mature foliage will always stand a stronger wash than young shoots, and that, as the full effect of the poison is not always observable until three or four days after the application has been made, it is better to err on the side of making the mixture too weak rather than too strong at first.

Whether, upon the whole, *London purple* or *Paris green* is the better agent to adopt for general use in India, is a question which it is difficult to decide upon the evidence at present available. Both have their advocates, and the circumstances under which it will be found preferable to apply one rather than the other can only be ascertained absolutely by experiment.

Pyrethrum.

This preparation consists of the ground-up petals of the flower of *Pyrethrum cinerariæ folium.* It is largely used for domestic purposes and can also be employed for the destruction of caterpillars in the open. It has the great recommendation of being harmless to animals other than insects, but is unfortunately too costly for general use, under ordinary circumstances, in the field. The following extract from *Notes on Economic Entomology*, Calcutta, 1888, gives the necessary particulars about its application :—

"*Pyrethrum cinerariæfolium*, a plant native to Dalmatia, has long been known to possess insecticide properties, especially in the powder from the dried and pulverised flowers. The species has proved to be hardy throughout the greater part of the United States, and Mr. Milco of St on, California, has for some years cultivated it extensively with considerable profit, the product being sold under the name of "Buhach." The insecticide properties reside in a volatile oil. It acts only by contact, and its action on many larvæ is said to be wonderful, a minute quantity in time paralysing and ultimately killing. Its influence in the open air is evanescent, in which respect it is far inferior to the arsenical products; but being perfectly harmless to plants, it can frequently be used on vegetables where more poisonous substances would be dangerous.

"Pyrethrum is supposed to have no effect on the higher animals. Dr. Riley's experience, however, is that fumes in a closed room have a toxic influence, intensifying sleep and inducing stupor; while the experience of Professor Bell with the powder copiously rubbed on a dog, showed that the animal was made sick and was affected in the locomotive organs very much as is the case with insects.

"The pulverised flowers are sold at about fifty cents per pound in America. The best method of using being to pour a quart of alcohol on a pound of the powder; leave it to stand for an hour and mix with forty or fifty gallons of water to be applied with a San José nozzle, or better to let the alcohol simply percolate through the powder and thus obtain a clear tincture, which can be applied with any nozzle. The powder may also be applied with bellows or mixed with water and applied by a pump."

Hydrocyanic Gas.

The Hydrocyanic gas treatment consists in throwing a moveable tent over the bush so as to confine the air and then fumigating the interior with Hydrocyanic gas. The gas is produced in the simplest possible manner by slipping inside the tent a saucer containing a little weak sulphuric acid into which a lump of potassium cyanide is dropped. The system has only been invented during the past few years, but is said to have already been adopted upon a very large scale for the destruction of scale insects upon orange trees in California. When carefully applied it is claimed to destroy, not only scale insects, but also almost every other form of animal life inside the tent, without injury to the orange tree, and it is likely to be almost equally satisfactory for tea bushes. In this case only a very small tent would be required and the whole process could easily be worked by a couple of coolies trained for the purpose. So promising indeed does it appear for use upon tea gardens that it is only surprising it has hitherto attracted so little attention.

The following extract from a report by Mr. D. W. Coquillet, published in the United States Department of Agriculture, Division Entomology, Bulletin No. 23, gives all the necessary particulars concerning the treatment, so far as orange trees are concerned. For tea bushes the only modification likely to be required is to reduce the size of the tent and to use proportionately less of the chemicals.

"Briefly speaking, this process consists in covering the infested tree with an air-tight tent, and afterwards charging the tent with hydrocyanic gas. The material commonly used in the construction of the tent is what is known as blue or brown drilling. A few persons have used ducking instead of the drilling, but this is much inferior to the latter; in the ducking the threads of which it is composed extend only lengthwise and crosswise, whereas in the drilling they also extend diagonally—this belonging to the class of goods to which our merchants apply the term "twilled"—and for this reason the drilling is both stronger and closer in texture than the ducking.

"After the tent is sewed up it is given a coat of black paint, as it has been ascertained that tents treated in this manner last longer than those which have been simply oiled with linseed oil. Some persons mix a small quantity of soap suds with the paint in order to render the latter more pliable when dry, and therefore less liable to crack; instead of thus painting the tent some persons simply give it a coating made of an inferior glue called "size," first dissolving this in water and then covering the tent with it, using a whitewash brush for this purpose. Sometimes a small quantity of whiting or chalk (carbonate of lime, $Ca\ Co_3$) is added to this sizing with or without the addition of lamp-black. A few make use of the mucilaginous juice of the common actus (*Opuntia engelmanni*, Salm.) for this purpose; to obtain this the cactus leaves or stems are cut or broken up into pieces, thrown into a barrel and covered with water, after which they are allowed to soak for three or four days; the liquid portion is then drawn off, and is ready for use without further preparation. Tents which I saw that had been prepared with this substance were to all appearances as air-tight and pliable as when prepared in any other manner.

"A tent 26 feet tall by 60 feet in circumference—a size large enough to cover the largest orange tree now growing in this State—if made out of drilling, and either painted or sized, as described above, will cost completed about 60 dollars. Where the trees to be treated are not more than 12 feet tall, the tent can be placed over them by means of poles in the hands of three persons; to accomplish this, three iron rings are sewed to the tent at equal distances around, and 6 or 7 feet from the bottom of the tent; immediately under each of these rings an iron hook is attached to the lower edge of the tent. When the latter is to be placed over a tree, each of the hooks is fastened into the corresponding ring above it; one end of a pole is then inserted into each of these rings, and the tent is raised and placed on the tree. The hooks are then released from the rings and the lower edge of the tent allowed to drop upon the ground.

"Instead of allowing the tent to rest directly on the tree, some growers use an umbrella-like arrangement, the handle of which is in two pieces, which are fastened together with clamps provided with pins; this allows the handle to be lengthened or shortened according to the height of the tree. This apparatus is put up over the tree, and the tent allowed to rest upon it. By the use of this simple device the danger of breaking off the small twigs on the upper part of the tree by the weight of the tent is avoided. Mr. Leslie, of Orange, used four tents and tent rests of this kind, and he informs me that with the aid of two men he fumigated 120 trees in one night. To remove the tent from one tree, place it over another, and charge the generator required only one minute and a half. In the place of poles some persons attach a circle of gas pipe to the lower edge of the tent; then two men, each taking hold of opposite sides of this circle, threw the tent over the tree. Dr. J. H. Dunn, of Pomona, informs me that four men, using six tents like the above, fumigated 240 orange trees in one night, and that the average for each night was over 200 trees, the latter being 8 feet or less in height. After the tent is placed over the tree, the next step is to charge it with the gas. The materials used for the production of the gas consist of commercial sulphuric acid ($K_2 SO_4$), fused potassium cyanide (KCN), and water, the proportions being one fluid ounce of the acid, one ounce by weight of the dry cyanide, and two fluid ounces of water. The generator is placed under the tent at the base of the tree; it consists of a common open earthenware vessel. The water is first placed in the generator, then the acid, and last the cyanide, after which the operator withdraws to the outside of the tent and the bottom of the latter is fastened down by having a few shovelfuls of earth thrown upon it. The tent is allowed to remain over the tree for a period of from fifteen to thirty minutes, according to the size of the tree.

"It was found by experimenting that the trees were less liable to be injured by the gas when treated at night than they were when operated upon in the day-time, and at the same time the gas is just as fatal to the scale insects when applied at night as it would be if applied in the day-time; and, indeed, it appears to be even more fatal when applied at night. This is accounted for by reason of the fact that in the day-time the light and heat decompose the gas into other gases which, while being more hurtful to the trees, are not so fatal to insects. At night the trees are also more or less in a state of rest, and, therefore, are not so liable to be injured by the gas as they would be in the day-time, when they are actively engaged in absorbing nourishment and replacing wasted tissue with new materials.

"Of the different materials used in generating the gas, the most important is the potassium cyanide; of this there are three grades; the mining cyanide, commercial cyanide, and the C. P. (chemically pure). Of these three brands, the mining cyanide is wholly unsuitable for the production of the gas, and the C. P. is too expensive; the commercial brand (fused) is the only one that is used for producing the gas, but even this varies greatly in strength, containing all the way from 33 to 58 per cent.

of pure potassium cyanide. It is, therefore, of the utmost importance that the operator should know the exact percentage of pure potassium cyanide that his cyanide contains, and when large quantities of it are purchased at one time it would be advisable to obtain one or more analyses of it by a reliable analytical chemist; or if it is not possible to submit the cyanide to such person, an analysis of it could be made by almost any person accustomed to the use of chemicals or drugs.

"The only substance required for this purpose is the crystals of nitrate of silver ($AgNO_3$), which may be obtained at almost any well-stocked drug-store. Dissolve the nitrate in cold water contained in a glass or earthen vessel, using one-fourth of an ounce (Troy) of the crystals to one pint of water; this dissolves in a few minutes, forming a whitish, semi-transparent solution. The cyanide, when dissolved in water, forms a transparent, nearly colourless solution; when a small quantity of the nitrate of silver solution is added to this it at first spreads out in a white cloud, like milk, but it soon breaks up into small, white, floccy pieces which gradually disappear upon being agitated, leaving the solution nearly as transparent as at first; when more of the nitrate of silver solution is added from time to time, the above process is repeated except toward the last, when the cyanide solution becomes somewhat milky, but it still remains semi-transparent, permitting the operator to see quite clearly the bottom of the vessel containing the solution. As soon as a sufficient quantity of the nitrate of silver solution has been added to the cyanide solution, the latter immediately becomes white and opaque, like milk, completely concealing from view the bottom of the vessel containing it. This completes the operation, and the quantity of nitrate of silver solution used will indicate the strength of the cyanide tested. When absolutely pure, $5\frac{3}{4}$ grains of the potassium cyanide dissolved in water will require one fluid ounce of the above nitrate of silver solution before the turbidity occurs, indicating that the cyanide is 100 per cent. strong; if only one-half of a fluid ounce of the nitrate of silver solution produces this turbidity, this indicates that the cyanide is only half strength, or 50 per cent. strong; if only one-fourth of a fluid ounce is required, then the cyanide is 25 per cent. strong; and so forth. The nitrate of silver solution should be added to the cyanide solution very slowly, the latter being agitated by gently shaking it each time that any of the nitrate solution is added. Wherever any of the nitrate of silver solution comes into contact with the skin or nails of the hand it produces a reddish or black stain, which can easily be removed by washing the stained part in a solution of cyanide and water; this will quickly remove the stain without causing any injury to the parts affected, except, of course, when the stains occur upon a sore or cut in the hand, in which case it would be dangerous to apply the cyanide to these places.

"It sometimes happens that the percentage of syanogen (CN or Cy) is given instead of the percentage of potassium cyanide (KCN or KCy); but in cases of this kind the percentage of cyanide can be readily ascertained by always bearing in mind that two-fifths of a given quantity of potassium cyanide is cyanogen. Thus, if a certain brand of cyanide contains 24 per cent. of cyanogen, this is equivalent to 60 per cent. of pure potassium cyanide. Potassium cyanide when absolutely pure (equal to 100 per cent.) contains 40 per cent. of cyanogen; and, therefore, no grade of cyanide could contain a larger percentage of cyanogen than this.

"The potassium cyanide used for producing the hydrocyanic acid gas is principally manufactured by two firms: Power and Weightman, of Philadelphia, Pa., and the Mallinkrodt Chemical Works, of St. Louis, Mo. That made by the first-named firm is the most largely used; when purchased by the ton the price is 36 cents per pound for the grade containing about 57 per cent. of pure potassium cyanide, packages and carriage extra. It is put up in tin cans holding 10 pounds each, and also in

barrels holding about 400 pounds each. That in the cans is much to be preferred, since the quantity in each is so small that it will soon be used up after the can is opened; whereas the barrel containing so large a quantity, the cyanide used towards the last will have lost much of its strength by contact with the air. It is customary to weigh out the cyanide in small paper parcels and mark each parcel with the number of ounces of cyanide that it contains: then when the tree is to be fumigated, it is an easy matter for the operator to select one of the parcels containing a sufficient quantity of the cyanide for the tree, thus saving the trouble of weighing out the cyanide as it is to be used for each tree. As the fumigating is done only at night, the weighing of the cyanide is frequently done by the ladies of the house upon the day preceding its use.

"The quantity of cyanide to be used on each tree will, of course, depend not only on the size of the tree but also on the strength of the cyanide used. The following table will aid in determining the proper quantity of each ingredient to be used on different-sized citrus trees, the cyanide being about 58 per cent. pure:—

Height of Tree.	Diameter of Tree-top.	Water.	Sulphuric Acid.	Potassium Cyanide.
Feet.	Feet.	Fluid ozs.	Fluid ozs.	Ounces.
6	4	⅔	⅓	⅓
8	6	2	1	1
10	8	4½	2¼	2¼
12	10	8	4	4
12	14	16	8	8
14	10	10	5	5
14	14	19	9½	9½
16	12	16	8	8
16	16	29	14½	14½
18	14	26	13	13
20	16	36	18	18
22	18	52	26	26
24	20	66	33	33"

Hopperdozers.

These appliances have been invented in the United States for the destruction of grasshoppers and other active insects which lurk in low vegetation. The value of the crops saved by the use of hopperdozers in the States of North Dakota and Minnesota alone in the year 1890 has been estimated by the Dominion Entomologist of Canada[1] at no less than two hundred thousand dollars. Hopperdozers are likely to be of use upon Indian tea gardens, not only for destroying grasshoppers in the weeds about the tea bushes, but also for catching such insects as the active larvæ of the mosquito blight which drop off the bushes when disturbed.

The forms in use in the United States vary a good deal in construction. The essential feature in each case, however, consists of an open pan

(1) See his address to the Association of Economic Entomologists, Washington, 1891.

containing either kerosine oil or coal-tar, which is drawn along over the ground in such a manner that many of the insects disturbed in its progress fall into the tray, where they are either entangled in the coal-tar from which they are unable to extricate themselves, or are poisoned by the action of the kerosine oil, which rapidly proves fatal to them.

The following extracts from an admirable report by Dr. C. V. Riley, United States Entomologist, on *Destructive Locusts*, Washington, 1891, give full information upon the subject of methods of construction and utilisation :—

"The pans that were used in Kansas and Iowa, but principally in the former State, were of very simple construction and very effectual.

"A good and cheap pan is made of ordinary sheet iron, 8 feet long, 11 inches wide at the bottom, and turned up a foot high at the back and an inch high at the front. A runner at each end extending some distance behind, and a cord attached to each front corner, complete the pan at a cost of about $1.50. . . . .

"We have known from 7 to 10 bushels of young locusts caught with one such pan in an afternoon. It is easily pulled by two boys, and by running several together in a row, one boy to each outer rope, and one to each contiguous pair, the best work is performed with the least labour. Longer pans, to be drawn by horses, should have transverse partitions . . . to avoid spilling the liquid; also more runners. The oil may be used alone so as just to cover the bottom, or on the surface of water, and the insects strained through a wire ladle. When the insects are very small, one may economise in kerosine by lining the pan with saturated cloth, but this becomes less efficient afterward, and frames of cloth saturated with oil do not equal the pans. Where oil has been scarce, some persons have substituted concentrated lye, but when used strong enough to kill it costs about as much as the oil. The oil pans can be used only when the crops to be protected are small.

"Small pans for oil, attached to an obliquing pole or handle, do excellent service in gardens.

"Mr. A. A. Price of Rutland, Humboldt County, Iowa, sends the Commission the following description of a coal oil pan to be drawn on runners, and which was used with much success in North Western Iowa. . . . Take a common board from 12 to 16 feet in length for the foundation or bed-piece. Make a tin trough 4 inches deep, 6 inches wide, and as long as required. Divide the trough into partitions by means of strips of tin, so that each partition is a foot long, thus avoiding the spilling of oil. Back of this place a strip of tin 16 inches wide and as long as the trough. The back must be firmly secured by braces running down to the front edge of the board. Under all this place three wooden runners 3 feet long and shod with iron for the trough to ride on. Fill the pan half full of water, and then add a small quantity of kerosine sufficient to cover the water. A horse may be hitched to the machine by fastening a rope to the outside runners. . . . . The lightness of the machine will allow of its being used on any crops." . . . .

"A machine of this sort was patented by Mr. Lorenzo B. Canfield, of Syracuse (Patent No. 187,509, dated Nebr., February 20th, 1877)." . . . .

"This pan was sold in the west at an exorbitant price, $4 being charged for royalty. Wherever we had an opportunity we advised farmers not to use it, but to construct others such as we have already described, and every bit as good, at far less

expense. The principle cannot be patented, for since 1875 similar coal-oil pans, virtual outgrowths of the canvas frames originally employed for the same purpose, have been 'known and used' in Colorado. This fact is sufficient in law to defeat any patent right based upon any application for a patent subsequent to such knowledge and use.

"The essential features in all the contrivances are in fact—(1) a platform that runs on the ground, on runners or wheels; (2) a canopy at right angles with it; (3) a reservoir at the junction to contain the liquid.

"Another pan . . . . was made by Mr. James Adams, of Abilene, Kansas. It is 10 feet long, 2 feet wide; back (*a*) 1 foot high; front (*b*) about 2 inches high at the inner edge; ends (*c*) 2 feet high. The front is made of a board 6 inches wide, leaning inward at an agle of about 45°. A cloth screen is placed on the back part which prevents the reel from knocking the locusts back over the pan.

"The whole is made of pine, and it costs $8 or $10. The pan is painted within with asphaltum paint, which renders it impervious to water or oil. The pan rests in front upon runners, to which ropes are attached for drawing, and on wheels behind which carry belts to turn the reel.

"The reel revolves just in front of the pan, causing the locusts to hop, and then knocking them into the pan. A brush of cloth is sometimes fastened to one arm of the reel to brush into the pan any locusts that may be on the front-piece. Several of these pans were used about Abilene, and did good work.

"A contrivance . . . . was constructed by President John A. Anderson for use on the Agricultural College farm at Manhattan, Kansas.

"It was found to do very good service, killing the young locusts in considerable numbers. The oil did not evaporate so rapidly as was anticipated. One thorough saturation was sufficient for fifteen or twenty minutes, when a little more could be added. If the machine be hauled against the wind, nearly all the locusts which hop will touch the oiled canvas. They generally take several hops upon the canvas before leaving it, thus ensuring a thorough saturation with the oil. After hopping from the apron they can take two or three hops upon the ground, then lose all power in their hind legs, stretching them straight out behind, and finally, in one or two minutes after being 'oiled,' they are dead.

"*Coal-tar.*—This may be used with most of the contrivances just described for the use of kerosine, and while not equal to the simple kerosine pan for speed in trapping and destroying, is yet very useful, especially in the neighbourhood of gas works, where the coal-tar can be obtained at nominal cost. It also permits the use of the simplest kind of pan. Enough tar is spread over whatever receptacle may be used to cover well the bottom, and when this becomes sufficiently matted with the young locusts so as no longer to destroy the new-comers, another coating is added, and so on until it becomes necessary to remove the whole mass, when it is shovelled from the pan and burned, or, what is far preferable, wherever there are wet ditches it may be thrown into these, when the oil contained in it, spreading over the surface of the water, destroys such locusts as may jump into or be driven into such ditches. Where the tar is scarce, as a matter of economy it will pay to melt the accumulated mass in iron vessels. By skimming off the dead locusts that rise to the surface, and thinning the residuum with a little coal-oil, it may be used again.

"A simple pan extensively employed . . . . was known as the Robbins 'hopper-dozer,' . . . the general plan being that of the ordinary road scraper. Its simplicity

and durability account for its general use. It was usually drawn by hand, though several pans were frequently bound together and drawn by horses; while, in some instances certain improvements in the way of mounting on wheels, so as to permit its being pushed from behind, were also adopted. We saw some with a wire screen or over hinge to the back, so that the insects might be secured when the pan was not in motion: but the cover seemed superfluous. We also saw lime and kerosine mixed so as to form a mortar substituted for the coal-tar."

CALCUTTA;
28th March 1894.

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